Product Development and Management for Engineers

GNG 2101 [D01]

Design Project User and Product Manual

Horizon Glasses

Submitted by:

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Table 1. Acronyms

Acronym	Definition
LED	Light-Emitting Diode
VCC	Power-Supply Pin
GND	Ground
UPM	User and Product Manual
BOM	Bill of Material

1 Introduction

This User and Product Manual (UPM) provides the information necessary for users with photophobia, athletes, engineers and all who's interested in using the dynamically polarized glasses and for prototype documentation. While these glasses were designed for anyone who likes the ability to switch the shade level of their sunglasses manually and automatically, the main focus is people who suffer from photophobia, organizations that help the issue and any future engineers who wish to pursue working on the product.

Throughout this document, the uses and functionalities of the glasses will be explained and earlier prototypes will be touched on for future students mainly. There will also be a section for recommended future work, this is in case any of the students are curious of where we imagined the product heading and would be interested in doing the same. The UPM is made for educational use in order to understand how to use the glasses and how they were made. For any future students who are interested in this project, this UPM will provide you with a step by step process of how team 1.3 got the product to this point. We recommend picking up where we left off and learning from our mistakes and not repeating them.

Notice:

- No warranties are given since the licence may not give you all the permission for intended use.

2 Overview

Everyone has some level of photophobia, while some have it more extreme than others. Up to 80% of the US and Canada’s populations fit under the description (eyes sensitive to light). Our client suffers from extreme photophobia, her eyes are sensitive to all kinds of light where she faces constant discomfort throughout her day. Her shades are always not dark enough or too dark for the setting she is in. Unfortunately, there is no current cure for photophobia, her main needs

were that; the glasses give her the ability to control the shade level manually, has the option to automatically adjust the tint level based on light intensity, and blocks all external light from entering without passing through the lenses first. These needs were necessary and were the whole basis for the project, and we have incorporated all these features into our final design.

Numerous research and benchmarking of other current sunglasses on the market that have remotely what we offer was conducted. While comparing our main features to those of the other team's and the companies on the market, our glasses stand out by a huge margin. First, we offer a wide front vision where the user's front vision will not be constrained by 2 small screens and we have 2 small side screens angled perfectly to maximize side vision while minimizing glare and bulkiness. When comparing this to other products on the market, our glasses stand out by miles, other glasses do not offer side vision covered by their screens. In addition, our screens will manually adjust their shade level based on the preference of the user, they are not limited by certain preset levels, the user is able to adjust slowly and stop where they like. Other screens on the market have 7-8 shade levels which defeats the whole purpose of manual adjustment technology. Moreover, our glasses block out almost all of the external sunlight from hitting the user's eyes before passing through the lens' first, this feature is uniquely incorporated into our design while minimizing bulkiness just as the user wished. When comparing this feature to the other team, our product is off the charts. The other team's glasses do not block most of the external sunlight which defeats the whole purpose of what the client is looking for. Lastly, our system is soldered together with very high precision, minimizing the clutter of the electronics.

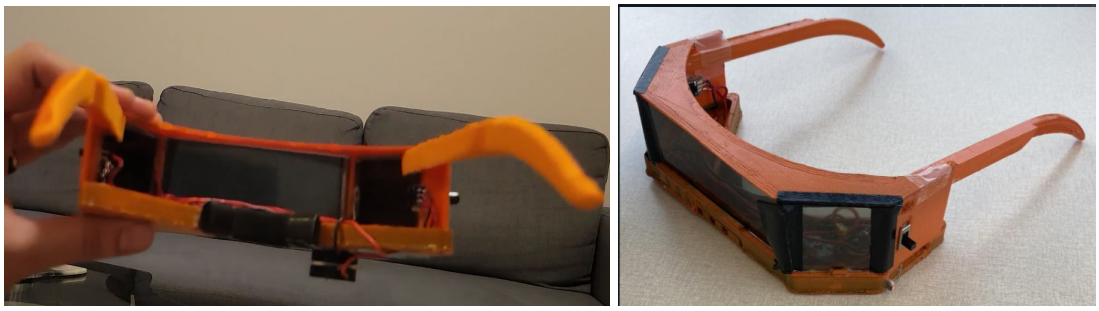

Figure 1. View of the glasses

As previously explained, the key features of our product include, the two 3V batteries, 3 screens, 1 large for front vision, 2 small angled perfectly to maximizing side vision and minimize the glare. A switch which allows you to switch between automatic mode and manual mode, a knob to control the tint level during manual mode and sensor to detect the light intensity.

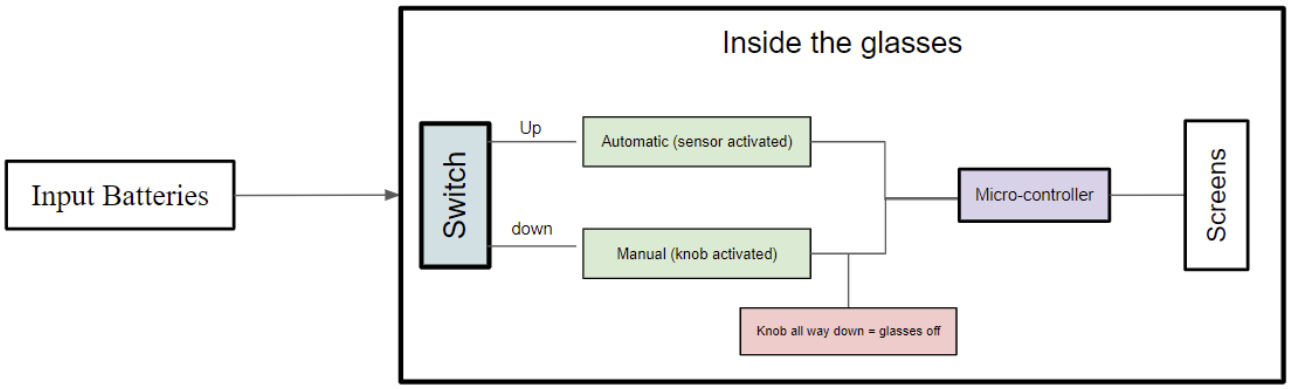

Figure 2. Block diagram of the glasses

2.1 Cautions & Warnings

- Handle the screens gently just as you handle any glass, however in the case a screen breaks, avoid touching the broken glass directly as it could cause bleeding.
- Do not utilize the glasses in temperatures below -30°C as it causes the crystal light valve to freeze and potentially damage the lenses permanently.
- Do not remove components as everything is connected very carefully.

- The product should not be worn in heavy rains or while swimming.
- Changing of batteries should be done gently so as to not damage wiring connections. While most parts of this product are replaceable, fixing the soldered parts requires extra tools.

3 Getting started

All the pieces listed below work together to provide the proper functionality of the Horizon glasses. The implementation of this project was inspired by the 3D Printed Electronic Sunglass [1].

Tools and supplies

- The microcontroller : Adafruit trinket- mini microcontroller 5V Logic
- The screens: Liquid crystal light valve-LCD Controllable Blackout Panel (x1 large, x 2 small)
- Batteries and Battery holder: Panasonic CR2032 3V lithium coin batteries (x2)
- Switch
- Manual knob: Linear taper potentiometer
- Photoresistor:
- 3D printed frames and arms

All these pieces work together to allow proper functionality of the dynamic frames

3.1 Set-up Considerations

The way the system works is described in ***section 4*** This is video is a short overview of how the glasses operate in this demonstration video

3.2 User Access consideration

Anyone in need of glasses that can tint shades level will be considered fit for a user. In our project, we target light sensitive patients with conditions such as photophobia, but Horizon glasses are very user-friendly and there are restrictions on the system of accessibility since there is an

automatic mode. However, this product **is not meant for children** since the electric components are not completely isolated and may be dangerous if toyed with.

The following block diagram predicts how the product is used by the user:

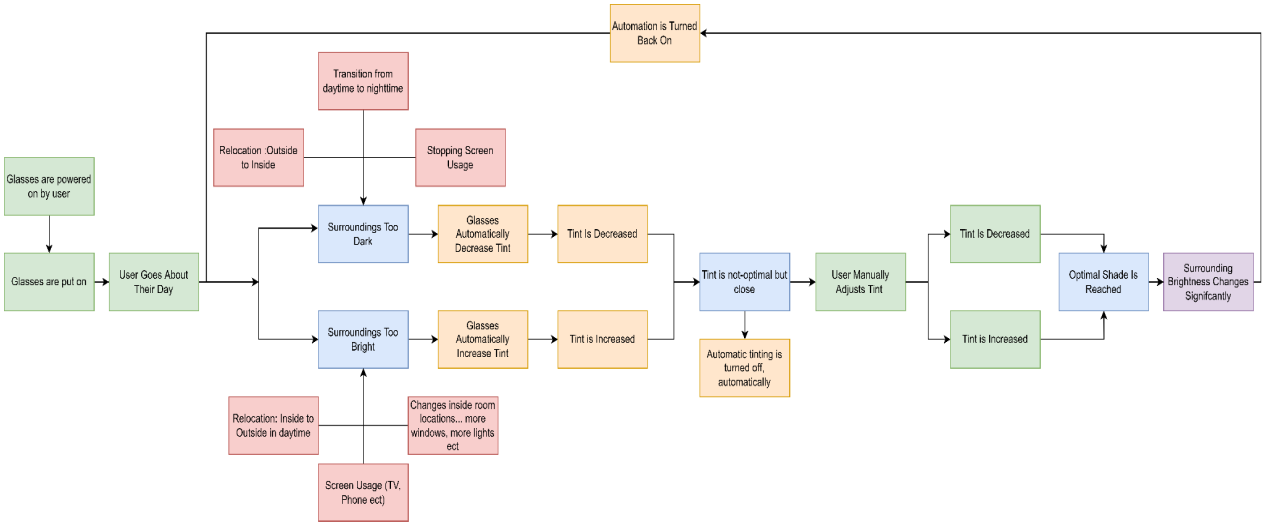

Figure 3. Block diagram of the glasses

3.2.1 Manual/Automatic Mode and Charging

The glasses can be used either in manual or automatic mode. Lowering the switch down enables manual mode and the potentiometer can be adjusted to lighten or dim the LCDs simultaneously. Turning the switch up enables the automatic mode in which case the tint level level of the LCDs is automatically adjusted based on the light intensity received by the photoresistor. Switching batteries can be done easily by connecting and disconnecting without electrical danger.

4 Using the Horizon Glasses

4.1 Toggling Mode Switch

This section will refer to both the right and left hand sides of the glasses. They refer to the sides with respect to a user wearing the glasses. The toggle mode switch is a simple 2-position switch on the left hand side of the glasses and toggles between the automatic and manual modes. Automatic mode will use a photoresistor mounted to the exterior of the frames to detect the ambient light level in the room and tint the LCD screens accordingly. Manual mode employs the use of a knob (potentiometer) mounted on the right side of the glasses who's operation is detailed as below. It is important to note that in the current configuration, the knob does not have any effect on the tint when the glasses are in automatic mode.

Figure 4. Right side view displaying switch and photoresistor

4.2 Manual Adjustment Knob

Mounted on the right hand side of the glasses is a knob which allows the user to adjust the tint of the screens once the glasses are in manual mode. The tint of the screen is proportional to the position of the knob - turning clockwise increases tint whereas counterclockwise decreases the tint of the lenses.

Figure 5. Left side view displaying potentiometer

4.3 Achieving Optimal Ergonomics and Light Reduction for Normal Use

Before putting the glasses on for normal use, it is important for them to rest on your face at the optimal angle for light blockage and at your desired orientation to maximize comfort. Firstly, insert both CR2032 coin-cell batteries into the battery slots mounted underneath the glasses, ensuring that the positive (+) terminal of the battery sits touching the positive side of the battery holder for each battery. Once this is done, switch the lenses into automatic mode and put them onto your face as you would a normal pair of glasses. Orient the glasses such that the screens are

perpendicular to your eyes while ensuring that they are still comfortable. Foam padding is used on the arms and nose to help with comfort.

5 Troubleshooting & Support

This section deals with troubleshooting and support for the design, if any problem arises.

5.1 Error Messages or Behaviors

Table 3. Corrective Measure to Errors

Error	Cause	Corrective Measure
Screens are constantly dark	Power Shortage to the screens themselves	Ensure coin cell batteries are not dead, try swapping out the batteries. If that fails, try looking at electrical connections between the batteries and the circuit board. Insure wires are securely connected to the ground and 5V pin located on the Arduino Nano
Screen darkness is fluttering between clear and black	Screens are getting a random burst of power and then not receiving any. Due to faulty connections and improper soldering	Try to play with the wires by moving them around. See which wires in particular affect the changing of the lenses.

Lenses Falling out of place	Wear and Tear	Add more adhesive glue to the perimeter of the lense. and place the lens back in place.
Glasses Arms Fell off	Wear and Tear	Add adhesive glue to the interior of the arm, and stick the arm back into place.

5.2 Special Considerations

It is important to keep in mind that the electronic components are delicate and not enclosed. Therefore, it is important to be careful not to pull on the soldered wires. Avoid wearing glasses on a rainy/ snowy day and exposing direct contact with other kinds of fluids to avoid damage.

5.3 Maintenance

The maintenance required is to store and operate the glasses at temperatures of 0℃ to 40℃ to ensure proper functionality. One can also disconnect the batteries after use to avoid quick battery discharge.

5.4 Support

In the case that user requires emergency assistance/support from our team, they can email Thomas Alkhoury, Brandon Sanford or Faraj Al Sabbah at their respective email addresses talkh099@uottawa.ca, bsanf077@uottawa.ca and falsa054@uottawa.ca .

It is best to format the support email as follow:

SUBJECT: Horizon glasses

PROBLEM: Describe the issue in as much detail as possible.

NOTES: include any other information such as the context, date on which the problem started.

PERSONAL INFORMATION: include name, email address/phone number of who is reaching out for assistance.

6 Product Documentation

The final prototype was a combination of a variety of components that each contributed to the overall functionality of the glasses. During the process, the project was divided into three main areas: electrical, software, and mechanical.

6.1 Electrical design

The figure below illustrates the arduino circuit used for testing the second prototype, however, this setting was updated and the wires were soldered on an Arduino Trinket 5V - 16 MHz . The circuit features a blue LED as the crystal liquid valve and a red LED as a status indicator. The red LED will illuminate when the setting is set to automatic adjustment, and will stop illuminating when the setting is manual adjustment.

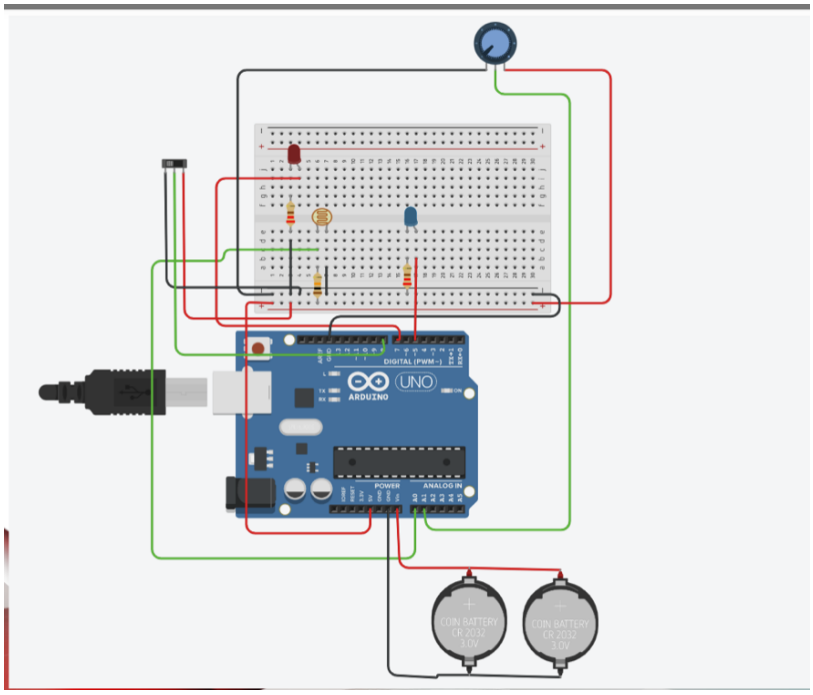

Figure 6. Circuit diagram displaying internal wiring

For the electronic functionality. The photoresistors we are using are cheap and relatively non-accurate to detecting appropriate light levels due to their high sensitvity. We assume that they will be accurate enough for our purposes. The photoresistors do not change analog readings by more than 3% for every 1% of light change. This analog reading needs to be confirmed once we have fresh photoresistors installed in our functioning circuit.

6.2 Software design

The glasses software was built by leveraging arduino IDE which is very accessible to different operating systems such as windows, Mac OS X, and Linux. The code below was written to allow toggling between manual and automatic mode during operating time.

Ultimately our team wanted to use an arduino nano which would have provided much smaller circuit boards. A suggestion to use a bluetooth module was made where the manual mode would

be adjusted using handheld smart devices. Our team decided that this would add an extra barrier of accessibility to those without smart devices and would have made the product more costly.

```
int photo = 0;
int LCDPin = 5;
int k = 100;
int threshold_brightness = 0;
int status_LED = 7;
int sliderPin = 8;
int potVal = 0;
int sliderVal = 0;
int LCDWrite = 0;

void setup(){
  Serial.begin(9600);
  pinMode(A0, INPUT);
  pinMode(A1, INPUT);
  pinMode(sliderPin, INPUT);
  pinMode(status_LED, OUTPUT);
  pinMode(LCDPin, OUTPUT);
}

void loop(){

  potVal = analogRead(A1);
  sliderVal = digitalRead(sliderPin);

  if(sliderVal == HIGH){ //automatic mode
    digitalWrite(status_LED, HIGH); //turn on status_LED
    Serial.print("Automatic ");
    photo = analogRead(A0);

    if (photo > threshold_brightness){
      LCDWrite = map(photo, 49, 969, 255, 0);
      analogWrite(LCDPin, LCDWrite);
      Serial.print(LCDWrite);
      Serial.print("\n");
    }
  } else {        //manual mode
      digitalWrite(status_LED, LOW); //turn on status_LED
      Serial.print("Manual ");
      potVal = analogRead(A1);
      LCDWrite = map(potVal, 0, 1023, 0, 255);
      analogWrite(LCDPin, LCDWrite);
      Serial.print(LCDWrite);
      Serial.print("\n");
  }
}
```

Figure 7. Functionality that allowed toggling between manual and automatic mode

6.3 Mechanical design

The glasses frames are 3-D printed using ABS. ABS is not a dense material and usually cannot hold a heavy load. When the frames were printed, the surface finish was rough and needed

to be sanded down on the exterior of the plastic. and add a surface coating, in order to allow for it to be smooth and not scratch the clients face. By doing these two surface treatments to the printed ABS, it allowed for a non-irritating surface to be created.

The design of the 3D frames was a tedious and iterative process that included many testing and reprinting. The frames were broken into 3 parts to ease printing and allow installation of LCDs. The combined pieces look like this :

- Soldering Iron and Solder
- Thermal resistant glue
- sand paper: to remove rough material for a smooth finish
- Flat pliers and utility knife: to remove rough supports from 3D printed parts
- Rubber covers : used as padding for the arms on frames.
- Foam sheet: used as padding material for nose cut
- Jumper wires

The dimensions in the configuration shown in figure 1 cover enough surface light incoming from front, sides , and underneath the eyes.

6.3.1 CAD Model Designs

The dimensions of the CAD's frame allow for enough space for the trinket, batteries, and the wires. Top of the glasses frame has a width of (10mm) and arm width(5mm). The arm thickness yields enough room for the potentiometer to be mounted and the top width yields enough room for the arduino trinket to be mounted as well. The photoresistor stays within the frame and since they are <1mm will have enough room to be mounted. The weight of the frames is approximately 54 g.

- Glasses Dimensions:
    - Left to Right (140 mm)
    - Top Ridge Depth (10 mm)
    - Nose Gap (7.5 mm)
    - Large LCDs (96.5 x 38.0 x 2.0) mm
    - Small LCDs (31 x 33 x 2) mm

- Arm Width @ Interface to the Lens (2.5cm)
- Arm Length (15cm)
- Arm starts to bend @ (2.5cm from Lense)
-

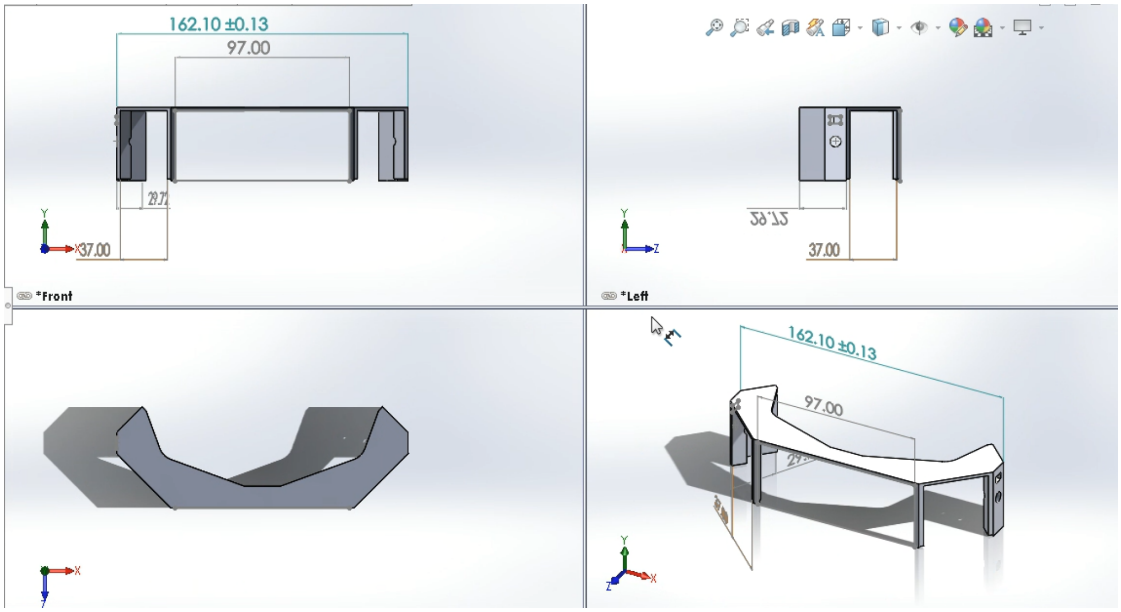

Figure 8. CAD Model of Top Half of Frames

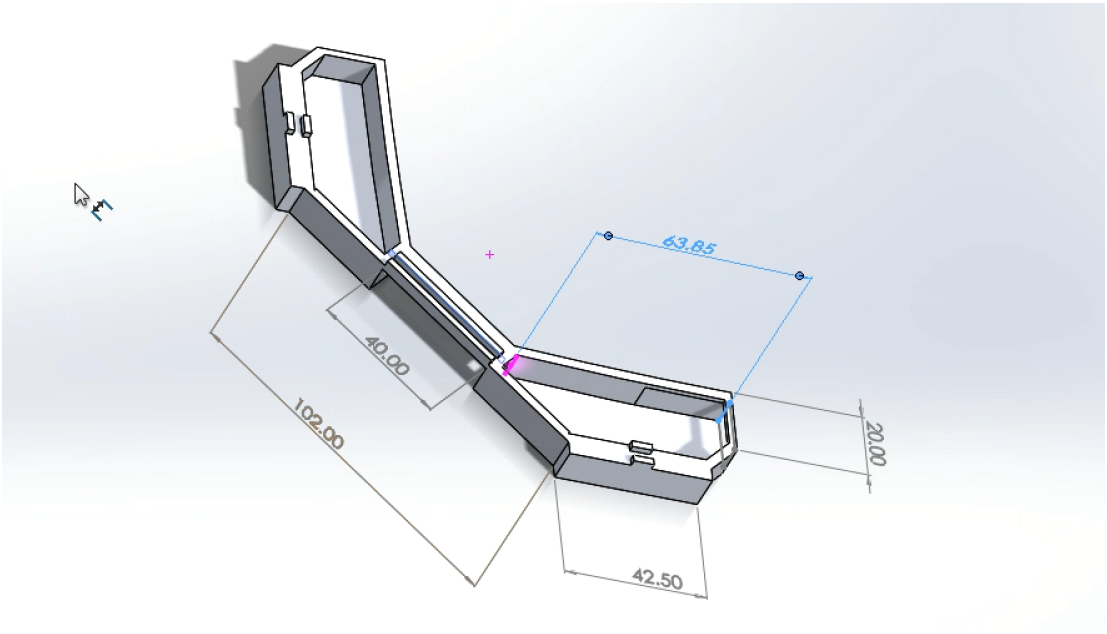

Figure 9. CAD Model of Bottom Half of Frames

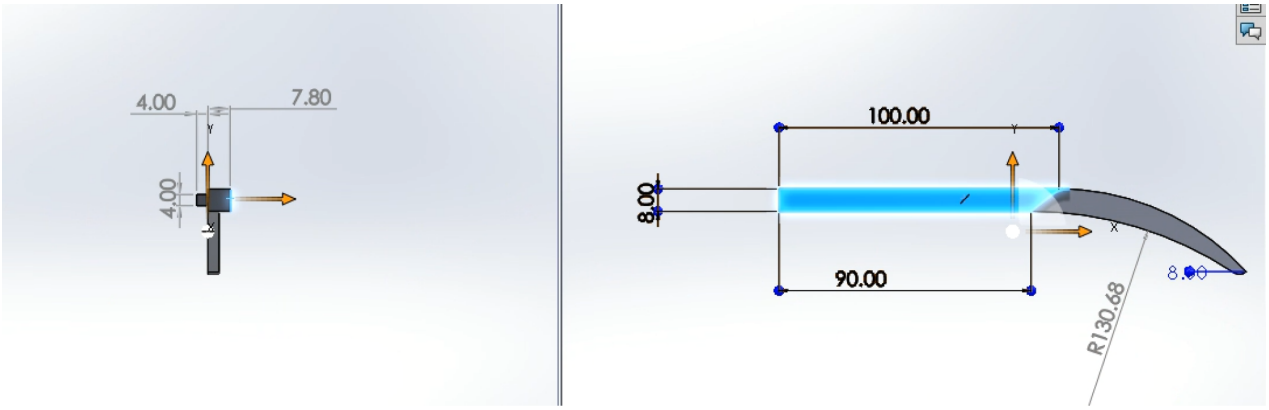

Figure 10. CAD Model of Arm

6.3.2 3D Printing

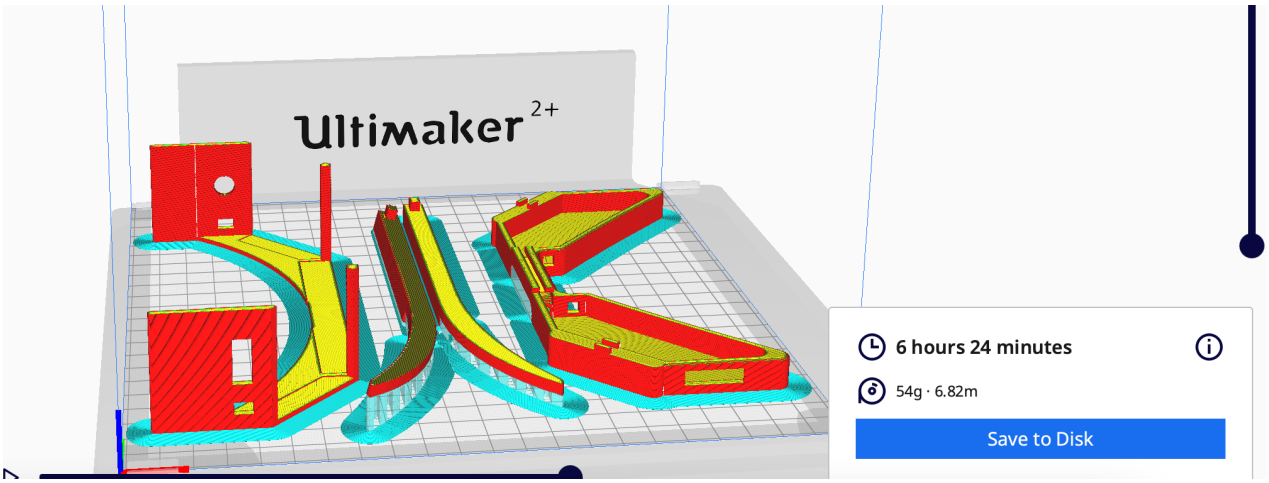

Figure 11. Preview of Frames showing Supports during 3D Printing

3D printing the frames necessitated more than 4 iterations as we kept adjusting the design to fit the LCDs and accommodate the rest of the components that were mounted on the bottom half part of the frames. The overall time to print was 6 hours and 30 minutes and figure 11 illustrates the orientation that was used to minimize printing time.

6.4 Building the Prototype

The following bill of materials is in reference to the final prototype and all components used in its composition.

6.4.1 BOM (Bill of Materials)

Table 4. Bill if Materials

Component	Dimensions	Quantity	Total Cost	Part Web Link
Panasonic CR2032 3V Lithium Coin Battery	10 mm	1	$8.90	Link
Potentiometer		1	$2.50	Link
Photoresistor	diameter thickness (1x 0.1) mm	2	N/A	-
Jumper Wires	N/A	30	N/A	-
Crystal Light Valves	refer to **section 6.3.1**	4	$11.80	Link
Thermal Resistant Glue	N/A	1	N/A	-
10 kΩ Resistor	N/A	1	N/A	-
220 Ω Resistor	N/A	1	N/A	-
Sliding Switch	-	1	$10.18	Link
Shapenty Plastic Battery Holder Cases for Coin Cell CR2032	(23 x 6) mm	1	$7.49	Link

Arduino Trinket 5V - 16 MHz	(31 x 15.5 x 5) mm	1	$5.50	Link
Frame	(162 x 39 x 27. 92) mm	1	$13.99	Link
3D Print Material		1	$0.0/gram	

6.4.2 Equipment

The list of equipment was mentioned under the tools and supplies in section 3 and also under section 6.4.16.4.1 BOM (Bill of Materials) in the BOM table.

6.4.3 Instructions

Section 6 provides full instructions on how the project was created and the tools one needs to replicate it. Section 3.2 describes how we predicted the user to use the Hozin frames.

6.5 Testing & Validation

Testing the Automatic Shading (Sensor Shading) and Manual Shading:

To test the prototype 1, we worked off of the fact that the LCDs material are transparent when 0V is applied across it and opaque when 2V is applied across it. By using the pwm function on the arduino, we manipulated the material into thinking less voltage is being applied across it, however we will just be modifying the pulse width.

The prototype test provided the results for the automatic shading testing first and then the manual shading testing. The automatic shading wasl be based on the light intensity detected by the photoresistor and the manual wasl be based on the value inputted by the potentiometer, i.e. how much did the user turn the potentiometer.

Table 6. Tests for Automatic Shading (Based on Light Intensity) click HERE for video

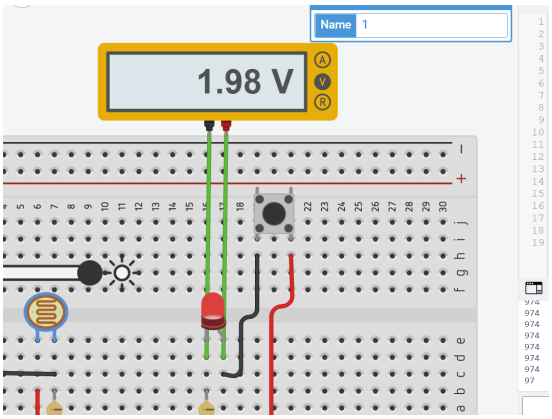

Figure 10: 99% Automatic VLT Blockage

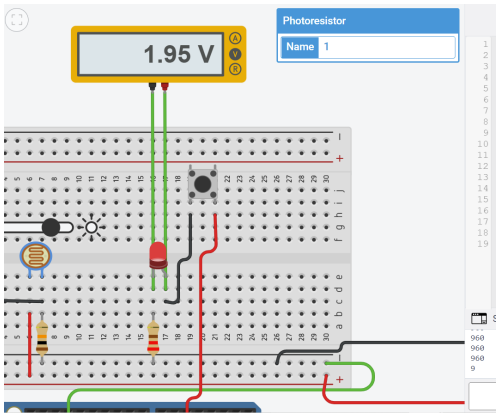

Figure 11: 97.5% Automatic VLT Blockage

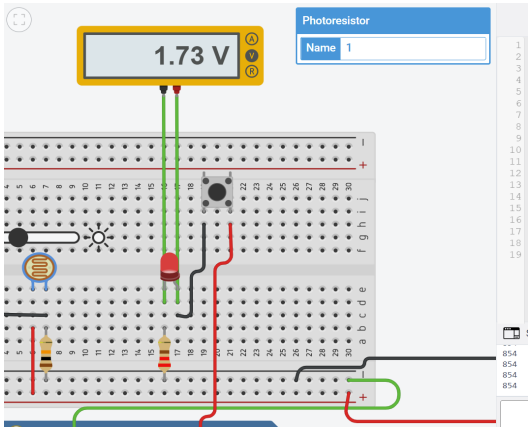

Figure 12: 86.5% VLT Blockage

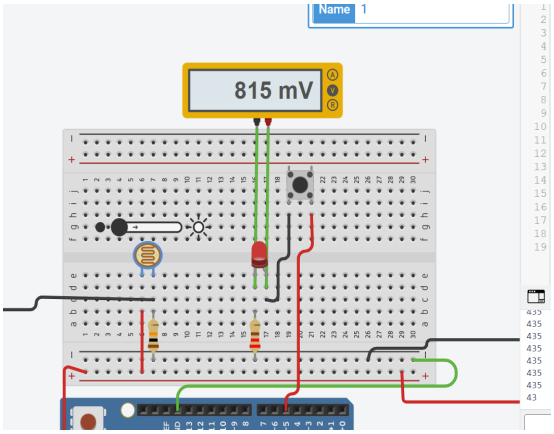

Figure 13: 40.75% VLT Blockage

Manual Shading (Based on Potentiometer "Dimming Switch") click HERE for video

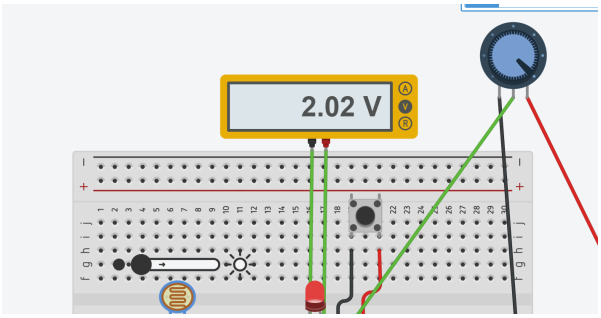

Figure 14: 100% VLT Blockage

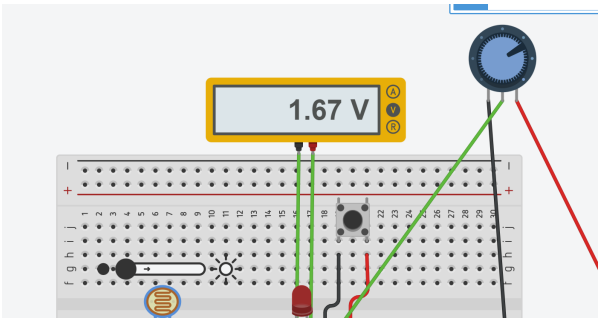

Figure 15: 83.5% VLT Blockage

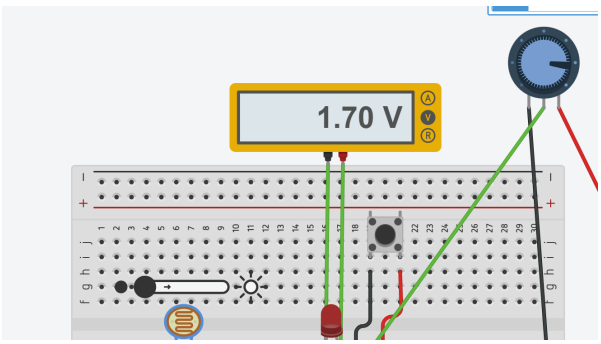

Figure 16: 85% VLT Blockage

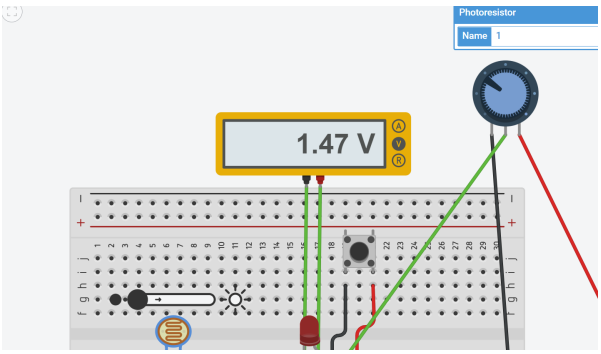

Figure 18: 73.5% VLT Blockage

The purpose of this prototype was to test whether the pwm (pulse width modulation) on an arduino can be utilized to control the voltage level across the material. Our team now demonstrated with an LED that the light level (shade level) of the LED can be controlled by the light intensity detected by the photoresistor as well as manually through a potentiometer.

7 Conclusions and Recommendations for Future Work

In a nutshell, this project allowed us to learn how to work together as a group. From the first client meeting we applied design criterias to understand what the client needs by carefully listening and applying empathy listening. We interpreted and organized these needs to develop a problem statement that guided our project. This course has allowed us to develop learning patterns when we are trying to understand the task at hand that would allow us to generate a product that people would want to buy. For future projects, we have learned that time management is key to having a successful product as the more the team is organized, more time for testing and the more iterations are done to polish the product. We now understand that it is to change plans for the better of the project as long as time management is accounted for.

Suggested Improvements on Frames

- Enclose the electronic components for better maintenance and overall usability of the frames.

- A large gap is noticed at the top as the top ridges do not cover enough to prevent light entering. 3-D printing a fitted top ridge would resolve this issue.
- Arms are not adjustable and it would be a good idea to redesign them to dimensions that would allow many users to wear them comfortably.
- Redesigning the nose gap for better comfort would also be a key improvement on the overall aesthetics of the frames.

Suggested Improvements on lenses

When tint level was changed, LCDs had a different level towards the middle of the lens and this was very noticeable during testing. A suggestion to look for a different brand of crystal light material that tints evenly would offer a better solution.

8 Bibliography

[1] R. Brothers, "3D printed electronic sunglasses," *Adafruit Learning System*. [Online]. Available: https://learn.adafruit.com/3d-printed-electronic-sunglasses. [Accessed: 11-Apr-2022].

APPENDICES

9 APPENDIX I: Design Files

Table 7. Referenced Documents LINK

Document Name	Document Location and/or URL	Issuance Date
GNG 2101- Deliverable A: Team Contract, Client Meeting, Preparation and Project Management Skeleton	https://docs.google.com/document/d/1SXtNV7noeq2QluaHbu3oayUy90r_CgMndUvdpcjNr8M/edit	January 16, 2022
GNG 2101- Deliverable B: Needs, Problem Statement, Metrics, Benchmarking and Target Specifications	https://docs.google.com/document/d/1p-xVGsmeLXvgwmohtOeHBQwXj4t8AmeayVwCukFDxW8/edit#heading=h.qwusesirpwp	January 23, 2022
GNG 2101- Deliverable C: Conceptual Design, Project Plan, and Feasibility Study	https://docs.google.com/document/d/1Ysjev9rVbbM7aH9oCJX_02gjeyLMXo-X11P2IDJbrVU/edit	January 30, 2022

GNG 2101- Deliverable D: Detailed Design, Prototype 1, BOM, Peer Feedback and Team Dynamics	https://docs.google.com/document/d/1XRVDPNW8xAVrs4VBooPpup3bGtB21UXwov5mP8FSK_o/edit	February 7, 2022
GNG 2101- Deliverable E: Project Progress Presentation	https://docs.google.com/document/d/1xxX9TjRidfDab01DrZ6ZbaRf3fAfnb6lOuotfgG2sAk/edit	February 13, 2022
GNG 2101- Deliverable F: Prototype 2	https://docs.google.com/document/d/1GVHVXzKTSMl0kbAIRSRMMBPUe_GvWC84EnWqv6bHahs/edit	March, 4, 2022
GNG 2101- Deliverable G: Business Model and Economics	https://docs.google.com/document/d/1sVcklmti_fFJgGObbWO26ngWWJr1T_8n4_-nuGWgpZg/edit	March, 18, 2022
GNG 2101- Deliverable H: Design Dat Pitch and Final Prototype Evaluation	https://docs.google.com/presentation/d/1814AHkq2Xdl9xscYt0061E5ztxx4vpSEByCo2oJiry0/edit#slide=id.p	March, 30, 2022
GNG 2101- Deliverable J: Final Presentation	https://docs.google.com/presentation/d/1814AHkq2Xdl9xscYt0061E5ztxx4vpSEByCo2oJiry0/edit#slide=id.p	April 8, 2022