GNG 2101 Project Report

Project Deliverable D: Detailed Design, Prototype 1, BOM, PeerFeedback and Team Dynamics

Submitted by

GNG 2101 - Lab C 02, Group 2.4

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Abstract

This deliverable is intended to demonstrate the conceptual design, produce the first prototype and include the Bill of Materials for the final prototype. Additionally, this Deliverable D discusses the information acquired at the second client meeting. According to BrightSpace, the goal is to "provide a thorough design with a bill of materials, create the first prototype, prototype test, display, and confirm that target requirements are satisfied."

1. Client Feedback

The client liked the first concept that we showed and she preferred the design that can automatically adjust brightness using electronics. Also, the client raised concerns regarding the durability / robustness of the electronics and whether the pair of glasses can be water resistant. She asked whether the glasses can handle winter temperatures (≤ 10°C) as well. Moreover, the client told us that her glasses are roughly 14 cm across from left to right side. Meanwhile, the frames of her sunglasses are not customized but the lenses are specialized. The client told us that her reading glasses and tinted glasses are different sizes, in which her reading glasses are 12.5 cm across with a lens of 6 cm. Furthermore, she wants to fit her reading glasses underneath the dynamically polarizing glasses.

2. <u>Detailed Design</u>

After the second client meeting, the provided feedback was used to update the project's design. The updated design uses a liquid crystal light valve (LCLV) to vary the visual light transmission of the lens. The level of tint displayed by the LCLV will be controlled by a microcontroller. A photoresistor mounted to the frame of the glasses will sense the ambient light and send that signal to the microcontroller. The microcontroller will vary the lens' tint in accordance with the ambient light. All of the electrical components will be powered using a small lithium ion polymer battery. All of the components will be housed in a TR-90 plastic frame. Moreover, the frame also contains a magnet to clip the client 's own reader glasses.

Based on the concept A and client meeting, we did some changes on air holes and replaced the inner holder with a magnet. Also, we changed the manual control to automatically change color with the microcontroller.

Table 3. Defined Subsystems for the Final Product

Subsystem	**Definition**
Lenses	Lenses are Liquid Crystal Light Valve plus anti-fogging coating.
Frame	The frame of prototype 1 contains rubber temple tips and air holes, of which the material is TR-90. For this prototype, we add one magnet to clip the client's reader lens.
Power System	The power system is to provide electricity / power to the dynamically polarizing glasses.
Control System	The control system is using a microcontroller to control the brightness of the glasses.

Benefits:

- Automatic tint adjustment
- Exchange lens

Trade Offs:

Requires battery power

Electrical components add weight to the design

Moreover, the design was refined so that it focuses on an electronics-based approach.

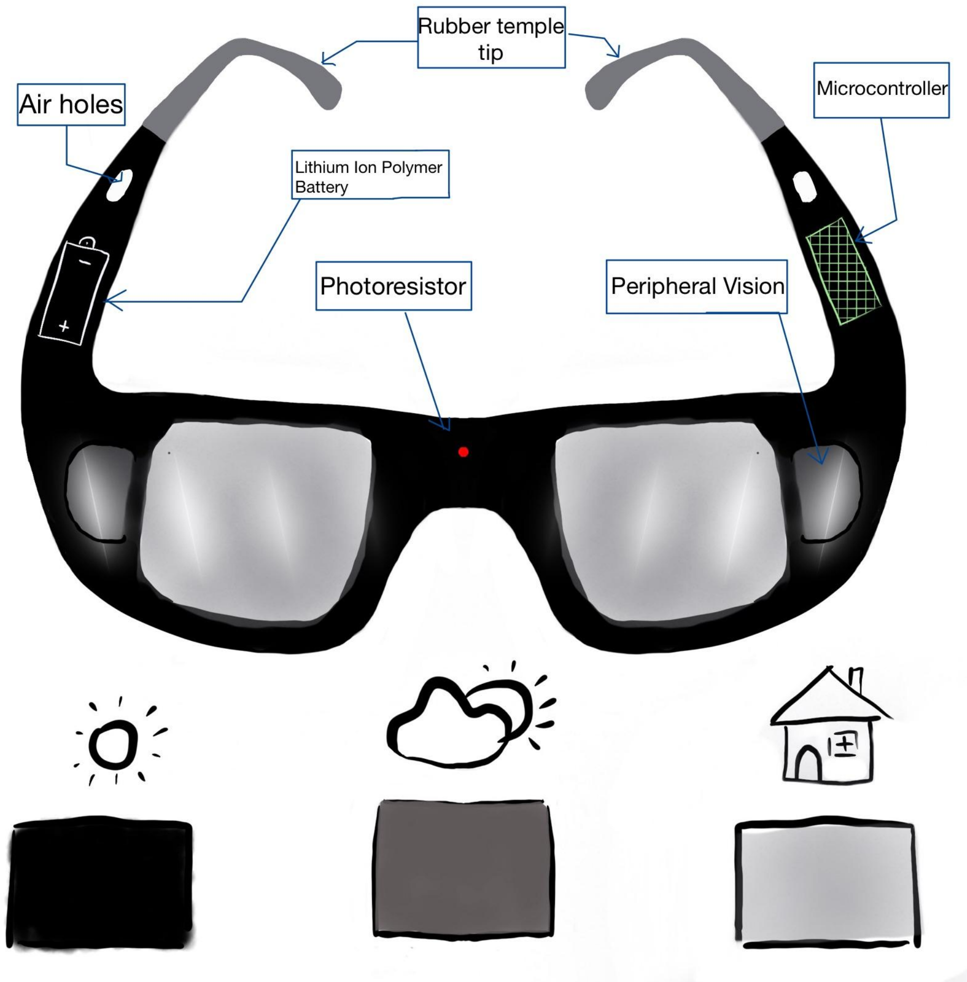


Figure 1. The sketches of first prototype

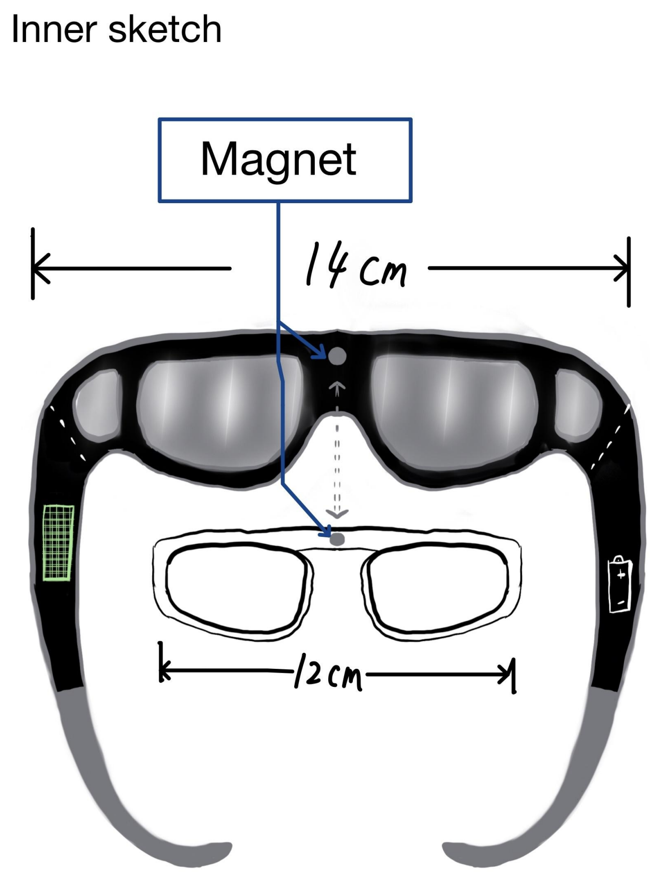


Figure 2. The dimensions of first prototype

In order for the lenses to support both automatic adjustment and manually adjustment, the design must incorporate multiple electronic components. Figure 3 illustrates the proposed electrical design for the product. The electrical schematic uses a photoresistor to measure the ambient light intensity, tactile buttons to receive user input, a microcontroller to process the sensor and button inputs, and 4 liquid crystal light valves to act as lenses for the sunglasses. The reason why 4 displays will be used is to provide the user with peripheral vision. Two of the lenses will be forward facing, while the other two displays will be angled so that they contour the user’s face.

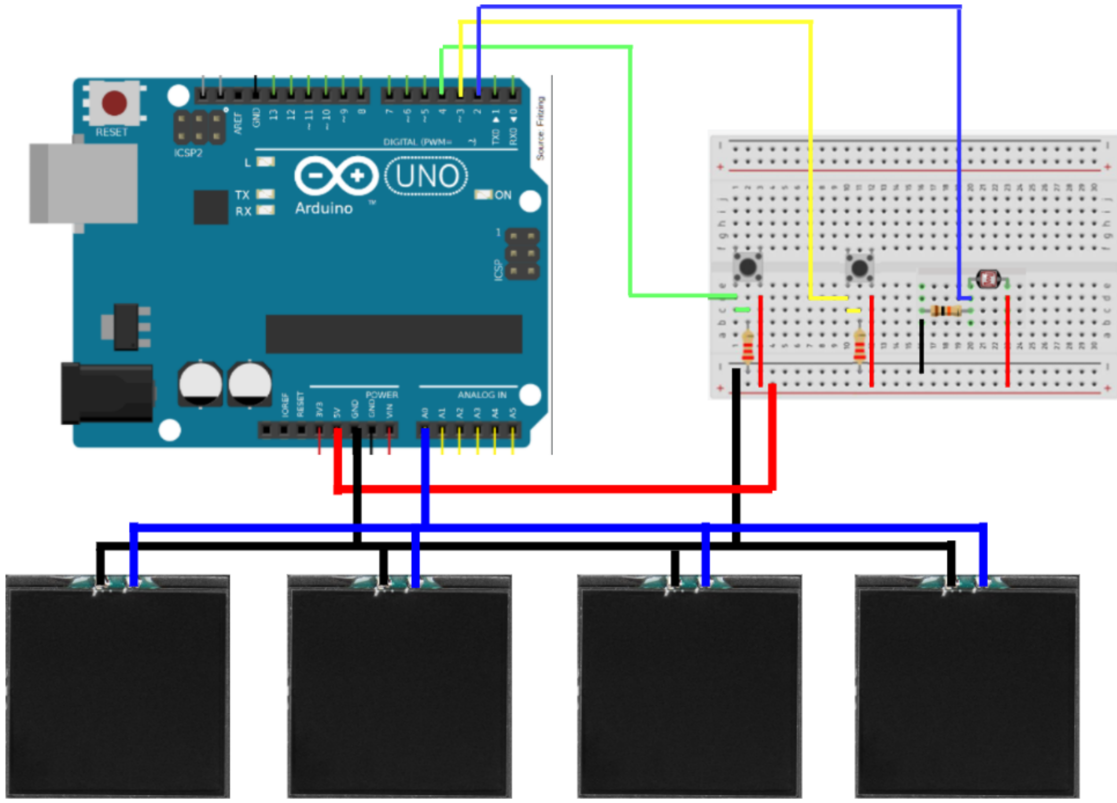


Figure 3. Electrical schematic for updated design

The microcontroller will need software to control the various electronic components. Figure 4 illustrates the proposed flow diagram for the products software.

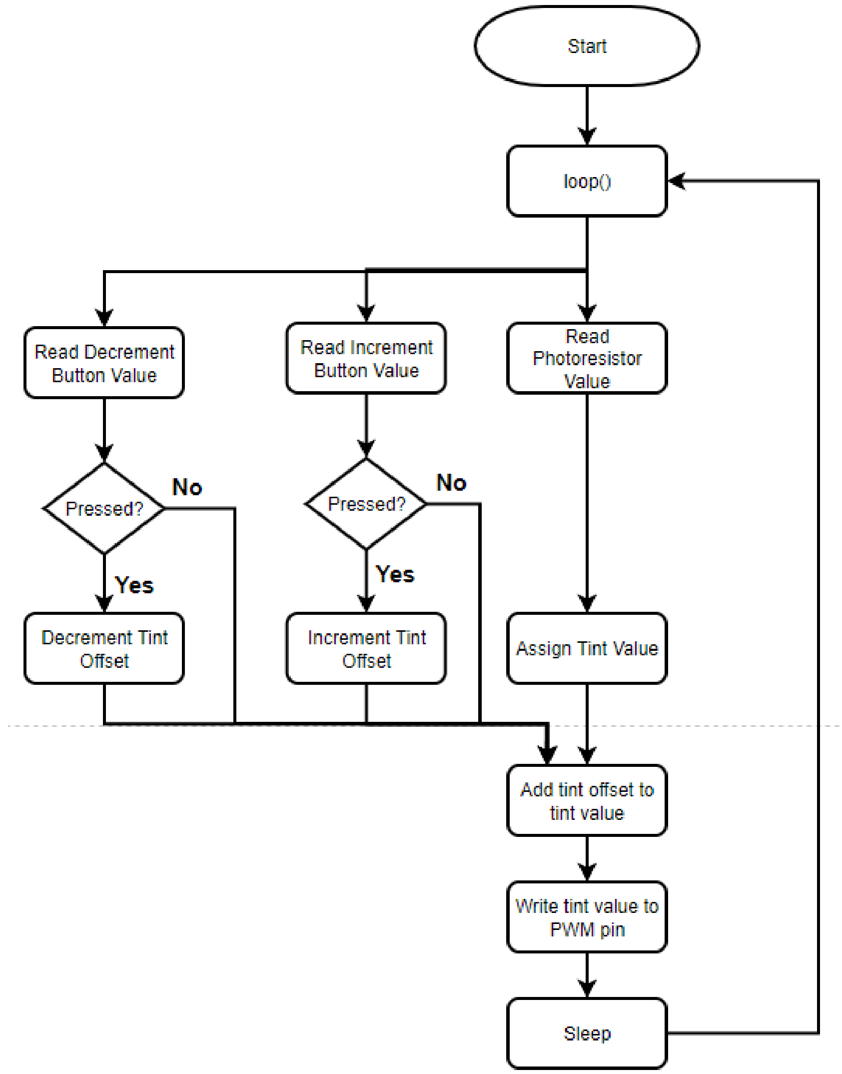


Figure 4. Software flow diagram for updated design

When the system is supplied with power, the microcontroller will initiate a loop to control the brightness of the sunglasses. The data from the photoresistor and the two buttons will be read. The software will first store the latest ambient light intensity measurement in a variable. Then it will check if the buttons have been pressed. If the increment button is pressed, a positive offset will be applied to the tint value. This will cause the lenses to become darker. If the decrement button is pressed, a negative offset will be applied to the tint value. This will cause the lenses to become brighter. Once the tint value is applied to the displays, via PWM signal, the microcontroller sleeps for a short period of time. Finally the program restarts over again.

3. Bill of Materials

Table 2. a detailed preliminary bill of materials and parts (BOM) for the final prototype

Type	Vendor	Description/ Dimensions	Price (CAD)	QTY.	TOTAL	Link	Purchased (Y/N)
Controllable Shutter Glass	Elmwood Electronics	A Liquid Crystal Light Valve (a.k.a a LCD Controllable Black-out Panel; LCD size: 31 x 33 x 2 mm; Dimensions: 36 x 36 mm ; Driving voltage: 3-5V)	$4.99	4	$19.96	Link 1	TRUE
Microcontroller, Adafruit Trinket M0	Elmwood Electronics	The Adafruit Trinket M0 is a tiny microcontroller board: 27mm x 15.3mm x 2.75mm / 1.07" x 0.6" x 0.1"; Height with MicroUSB: 3.5mm / 0.14"; Weight: 1.4g	$12.99	1	$12.99	Link 2	FALSE
Anti-fogging Coating	Amazon	Product appearance: blue; Product active layer color; transparent; UV protection rate: 35%; Visible light reflectance: 35% Light transmittance: 99%; Insulation rate: 50%;	$14.99	1	$14.99	Link 3	FALSE

TR 90 Glasses Frame	UOttawa 3D printer	TR90 is a thermoplastic material that is incredibly durable, flexible, and lightweight.	$0.00	1	$0.00	Link 4	TRUE
Tactile Switch Buttons	Elmwood Electronics	Medium-sized clicky momentary switches are standard input "buttons" on electronic projects; The pins are normally open (disconnected) and when the button is pressed they are momentarily closed.	$3.99	1	$3.99	Link 5	FALSE
Rubber Temple Tip	Amazon	Eyeglass Strip Silicone Ear Stirp, Sleeve Retainer for Glasses, Sunglass(Black): Item Weight 20 g; Parcel Dimension 7 x 4 x 0.2 cm; 20 Grams	$7.55	1	$7.55	Link 6	FALSE
Lithium Ion Polymer Battery	Elmwood Electronics	3.7V 350MAH	$9.99	1	$9.99	Link 7	FALSE
Total product cost (without taxes and shipping)					$69.47		
Total product cost (including taxes and shipping)					$78.50		

4. Product Assumption

Table 3. Target specifications

Metrics ID Number	Metrics Descriptor	Units	Actual Values
1	Cost	CAD	$ 78.50
2	Weight of the glasses	g	< 26 g
3	System response time	s	< 0.1 s
4	Visible Light Transmission (%)	*Unitless*	4% - 38%
5	Battery Life	days	> 7 days
6	Cold Weather Durability	℃	>-20℃

For this project, the assumption is that an electrochromic display (Liquid crystal light valve) can be utilized to vary the amount of light being transmitted through the glasses.

Notes:

Cost:

➢ The other products compared during benchmarking were under $100, which is ideal for this project.

Weight

➢ Some glasses were between 21g - 26g, but the prototype needs to be lighter than that.

Response Time

➢ The electrochromic glasses by Ampere can adjust its tint in less than 0.1s. The prototype will ideally have a similar or better response time.

Visible Light Transmission (VLT)

- ➢ The client mentioned that her darkest glasses have a VLT of 5% and her lighter sunglasses are approximately 13% (Cocoon sunglasses). Thus, the marginal VLT should range from approximately 5% - 15%.
- ➢ The electrochromic glasses by Ampere have a VLT range from 4% to 38%, so the ideal design should have a similar VLT range.

Battery Life:

- ➢ Ideally, the prototype's design should have a similar battery life to the electrochromic glasses by Ampere, which is 7 days.

5. First Prototype Creation

The purpose of the first prototype is to validate the main assumptions that were made when producing the design and ensure that the design meets the critical target specifications, and to assess the feasibility of an electronics-based design to automatically adjust the brightness of the sunglasses. This initial prototype consists of a photoresistor to sense the ambient light, two liquid crystal light valves to act as adjustable lenses, and an Arduino Uno microcontroller to read the sensor data and control the displays. The following electrical schematic illustrates the connections between the various components.

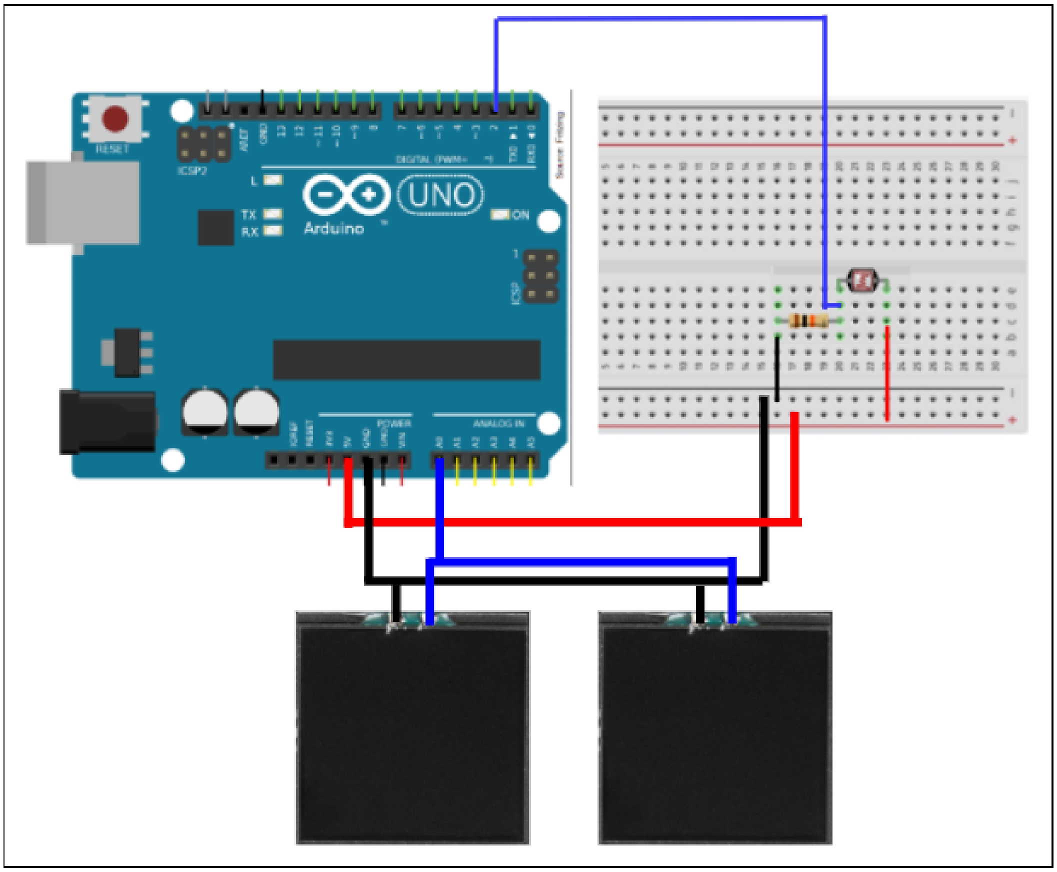


Figure 5. Electrical schematic of first prototype

A photoresistor is connected to one of the digital input pins of the Arduino Uno. The Uno reads the ambient light value and scales the tint of the lenses accordingly. For example, when a large amount of light is measured by the photoresistor, the Arduino increases the tint of the lenses and vice-versa.

Two liquid crystal light valves (LCLV) are used to represent the two lenses of the sunglasses. These are controlled via pulse width modulation (PWM) signals sent from the Arduino Uno. The PWM signal is used to effectively control the brightness of the displays by increasing and decreasing the voltage applied to the LCLV pins.

The following software flowchart illustrates how the lenses are controlled.

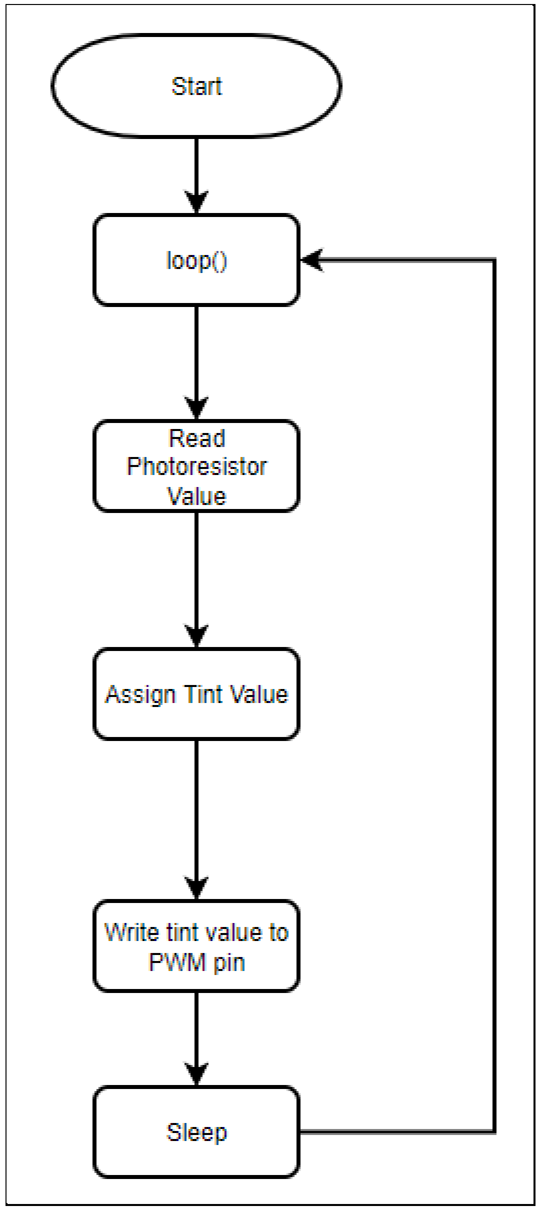


Figure 6. Electrical schematic of first prototype

The software running on the Arduino performs a sequence action continuously while power is being provided. First, the Arduino reads the ambient light data from the photoresistor's digital pin. The ambient light value is stored in a variable. The ambient light value is converted to a corresponding PWM value and is written to the LCLV's analog pin. Finally, the program sleeps for a short period of time and then restarts the loop.

The following figure illustrates the constructed prototype.

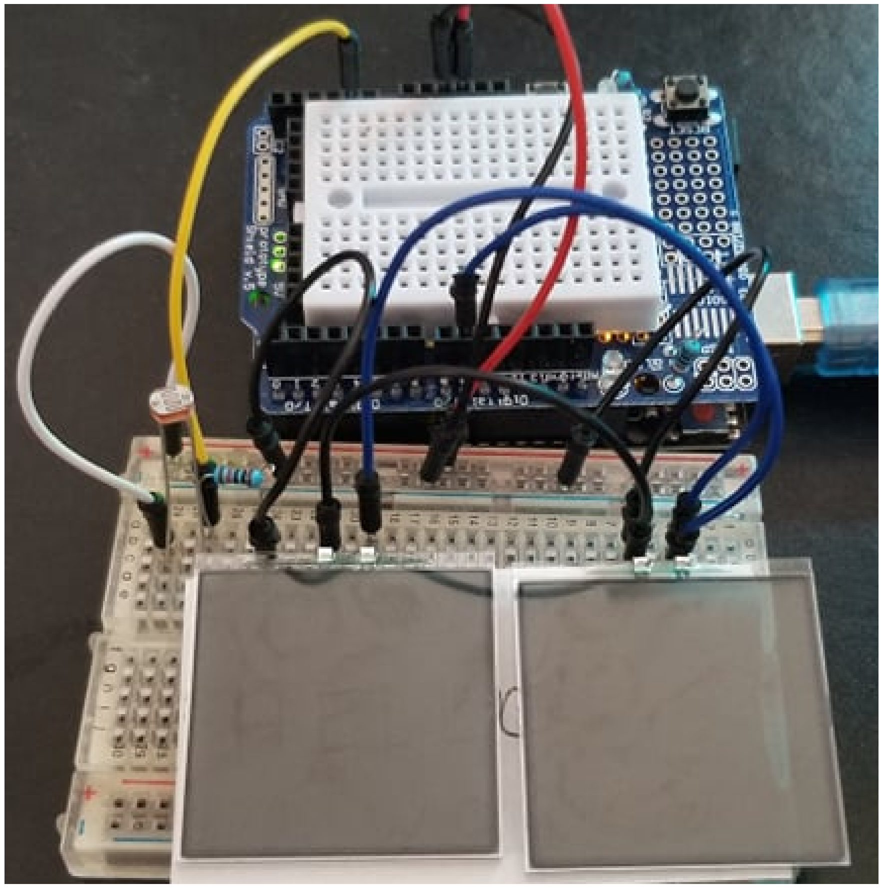


Figure 7. First prototype constructed on a breadboard

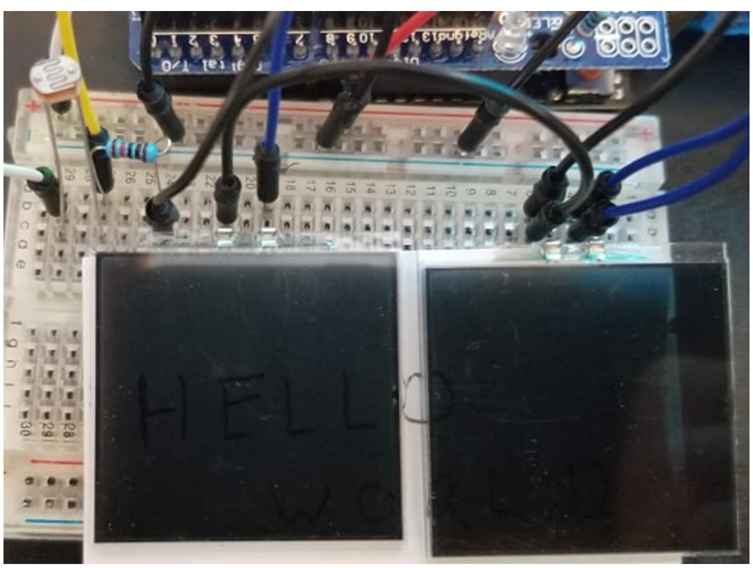
6. First Prototype Testing:

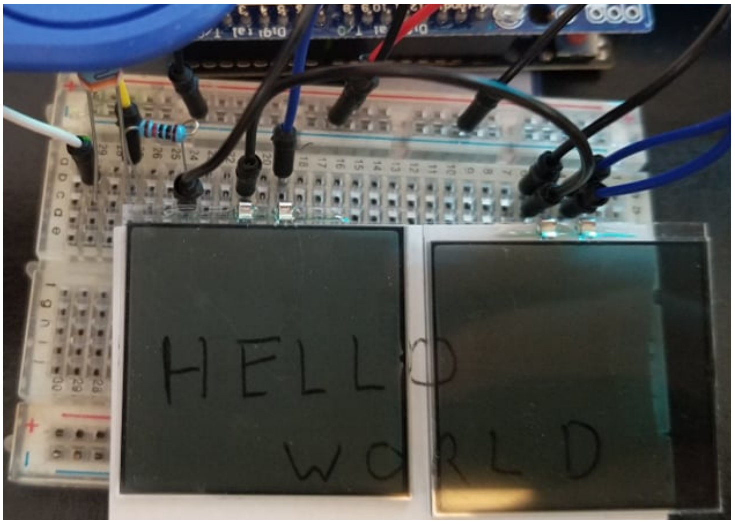
The main target specifications that the first prototype aims to test are the visible light transmission (VLT) percentage of the lenses as well as the response time of the system. Additionally, we will test the cold weather durability of the electronics.

6.1 Visible Light Transmission Test:

In order for the sunglasses to meet the client's needs, the visible light transmission of the lenses must be able to adjust from 5% VLT to approximately 38% VLT. It was not possible to quantitatively measure the visible light transmission of the lenses under different operating conditions, since we lacked the measurement devices that are commonly used for such tests. As such, the test results are based on information from the liquid crystal light valve datasheet as well as qualitative observations. The first prototype was exposed to three different testing conditions: brightly light environment, normal light environment, and shaded light environment. The following table includes the results of these tests.

Table 4. Visible light transmission test under various light conditions

Light Environment	Results	Comments
Bright		- Under brightly lit conditions, the LCLV blocks almost all of the light. - According to the data sheet of the LCLV, the display has 5% VLT when 5V is supplied to the input pins.
Normal		- Under normal lighting conditions, the LCLV blocks most of the light.

Shaded		- Under shaded lighting conditions, the LCLV lets most of the light through the display.

The testing performed for the first prototype yielded qualitative evidence demonstrating that the liquid crystal light valve can meet the 5%-38% VLT target specification.

6.2 System Response Time Test:

Another target specification the first prototype was designed to test is the response time of the system. The response time is a measurement of how long it takes for the glasses to adjust their brightness in accordance to a change in ambient light intensity. In order to measure the response time of the system, a time stamp was recorded each time the Arduino measured the ambient light. The following figure illustrates the raw data outputted by the Arduino.

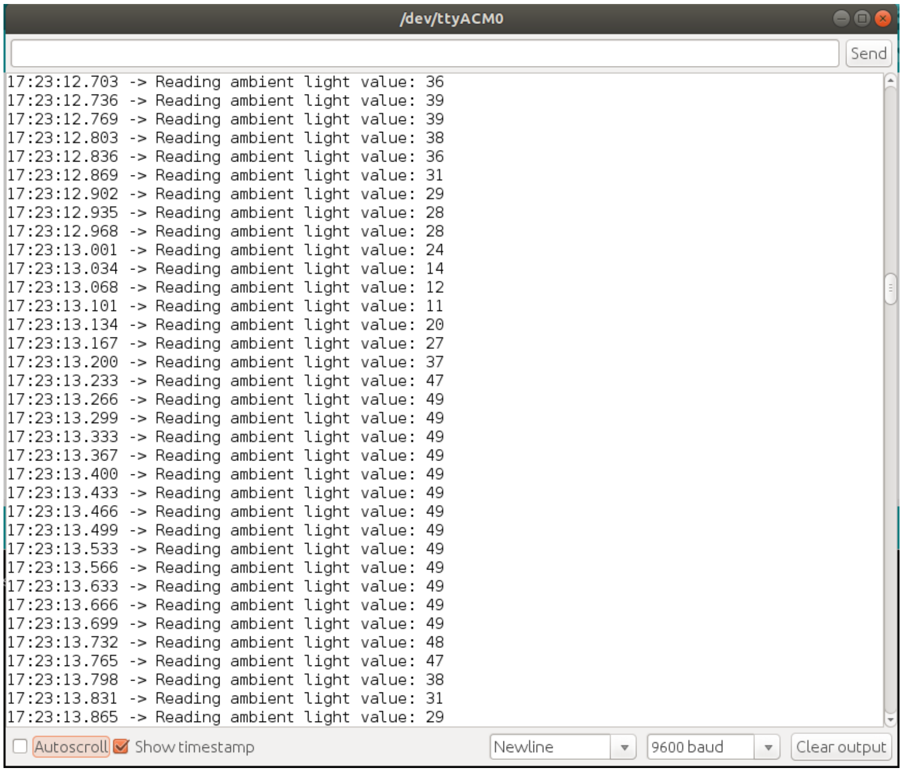


Figure 8. Arduino response time data

The average response time was calculated from the raw data and compared to the marginal and ideal target specifications.

Table 5: First Prototype Response Time Results Compared to Marginal and Ideal Specifications

First Prototype Response Time	Marginal Values	Ideal Values
0.033 s	< 60 s	< 0.1 s

The first prototype was able to yield a response time that surpasses the ideal target specifications.

6.3 Cold Weather Durability Test:

Finally, the last specification that was tested by the first prototype is cold weather durability. Since the client expects to use the sunglasses during the winter, where temperatures are regularly below 0℃, the electronic components must be able to operate for prolonged periods in the cold. To test the cold weather durability, the first prototype was powered with a battery pack and placed outside for 4 hours. The goal of the test was to ensure that the liquid crystal light valves would continue to operate when placed in the cold environment. When the test was conducted the outside air temperature was approximately -8℃

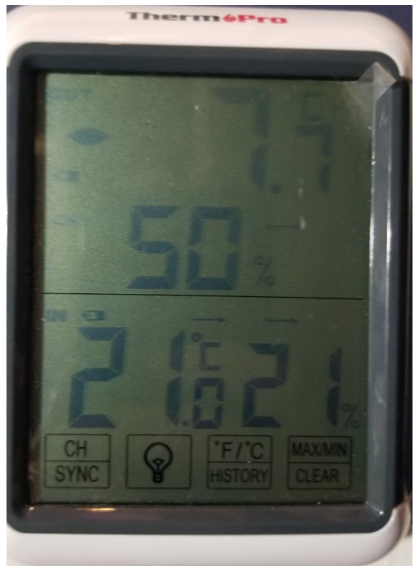
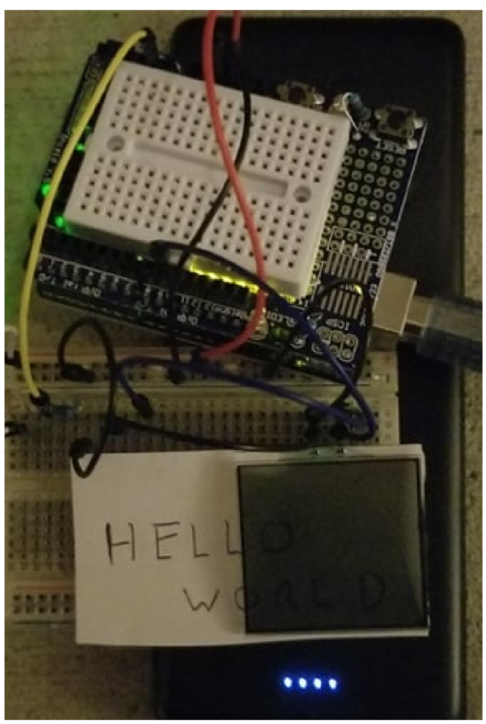


Figure 9. Air temperature measurement

After exposing the electronics to the cold air for 4 hours, the visual light transmission test was repeated. First the flash from a camera was used to mimic a bright light source. The system's response was observed. Then the system was exposed to the ambient lighting conditions (dimly lit) and the system's response was observed. The following table describes the qualitative results.

Table 6: Qualitative results after performing the cold weather durability test

Light Environment	**Results**	**Comments**
Bright		- A camera flash was used to mimic a bright light source. - The system successfully adjusts the LCLV brightness to block the bright light.
Dim/Night		- Under dimly lit conditions, the system adjusts the LCLV brightness to allow most of the light through the lens.

This test serves to demonstrate that the system can withstand cold weather exposure for a prolonged period of time and continue to function as expect.

7. Conclusion

As the client preferred the first design, prototype 1 will have a more electrical design that will automatically alter the brightness of the sunglasses. According to the Bill of Material (BOM) statistics, the material for the first prototype costs $ 78.50 (plus taxes), which is a reasonable amount for the budget. This prototype, in particular, seeks to employ an overall adjustable system consisting of a microprocessor, a photoresistor, and a lithium ion polymer battery that links the different components and enables users to change the light transmittance of the glasses by just pressing a button. Furthermore, the client expressed concerns about battery life, especially in cold weather, and the requirement to wear her reading glasses below the dynamically polarising lenses, both of which will be addressed in the next prototype.

8. Project Plan

GNG 2101 C#02 Group 2.4

List | Table | Gantt Chart

All tasks | By Priority | Expand/Collapse

Title	Assignee	Status	Start date	Due date	Duration
GNG 2101 C#02 Group 2.4	Dongyu Wang	In Progress			
Closing					
PD I: User manual		New	04/04/2022	04/10/2022	7d
PD J: Final presentation		New		04/05/2022	
Execution					
PD A.2: Client meeting preparation	Avery Lai, Dongyu Wang, Ken Lorbet...	Completed	01/10/2022	01/16/2022	7d
PD A submission	Avery Lai	Completed		01/16/2022	
Client meet 1	Avery Lai, Dongyu Wang, zhema wen...	Completed		01/17/2022	
PD B: Needs	Ken Lorbetskie, Dongyu Wang, zhem...	Completed	01/17/2022	01/23/2022	7d
PD C: Concepts	zhema wen, Avery Lai, Dongyu Wang...	Completed	01/24/2022	01/30/2022	7d
Client meet 2	Dongyu Wang, zhema wen, Ken Lorb...	Completed		01/31/2022	
PD D: Detailed design	Dongyu Wang	Completed	01/31/2022	02/06/2022	7d
PD E: Project progress presentation		In Progress	02/07/2022	02/17/2022	11d
Client meet 3	Avery Lai, Ken Lorbetskie, zhema wen...	New		02/28/2022	
PD F: Prototype 2		New	02/28/2022	03/06/2022	7d
PD H: Design day		New		03/30/2022	
Initiation					
PD A.1: Team contract	Ken Lorbetskie, Avery Lai, zhema wen	Completed	01/10/2022	01/16/2022	7d
Monitoring and Control					
PD A quality check	Avery Lai	Completed	01/10/2022	01/16/2022	7d
PD B quality check	Ken Lorbetskie	Completed	01/17/2022	01/23/2022	7d
PD C quality check	zhema wen	Completed	01/24/2022	01/30/2022	7d
PD D quality check	Dongyu Wang	Completed	01/31/2022	02/06/2022	7d
PD D projet plan update	Dongyu Wang	Completed	01/31/2022	02/06/2022	7d
PD E quality check	Avery Lai	In Progress	02/18/2022	03/01/2022	12d
PD E project plan update	Dongyu Wang	New	02/07/2022	02/17/2022	11d
PD F quality check	Ken Lorbetskie	New	03/07/2022	03/23/2022	17d
PD F project plan update	Dongyu Wang	New	02/18/2022	03/06/2022	17d
PD G quality check	zhema wen	New	03/21/2022	03/27/2022	7d
PD G project plan update	Dongyu Wang	New	03/14/2022	03/20/2022	7d
PD H quality check	Dongyu Wang	New	03/21/2022	03/30/2022	10d
PD I quality check	Avery Lai	New	04/10/2022	04/10/2022	1d
PD J quality check	Ken Lorbetskie	New	03/28/2022	04/05/2022	9d
PD J project plan update	Dongyu Wang	New	03/30/2022	04/05/2022	7d
Planning					
PD A.3: Project skeleton	Dongyu Wang	Completed	01/10/2022	01/16/2022	7d
PD C.2: Project plan	Dongyu Wang	Completed	01/24/2022	01/30/2022	7d
PD D.1.8: BOM	Dongyu Wang, zhema wen, Ken Lorb...	Completed	01/31/2022	02/06/2022	7d
PD G: Business model and economics report		New	03/14/2022	03/20/2022	7d

Figure 10. The updated version of the plan

9. Reference

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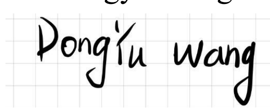
10. <u>Personal Ethics Statement</u>

a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*
b) *I understand that I am obligated to abide by these terms and conditions.*
c) *I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.*

Signatures - - - - - - - - - - - Date: February 06 / 2022

Avery Lai: 	Kenneth Lorbetskie: 
Dongyu Wang: 	Zhema Wen: