Electric Blind

Initial Project and Group Identification Document

Divide and Conquer

Group 13

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Project Narrative

Every day, the march of progress moves forward. Technology improves each day, and humanity reaps the rewards. As this progress moves forward, technology is integrated into our lives at an increasing rate. One day we start carrying flip phones in our pockets, the next we are asking Alexa to order us some toilet paper before it runs out. This project aims at moving that march forward a step. We will accomplish this feat via integrating technology in a meaningful way into people's life that they can derive use from. Virtually everyone in America spends some of their times in buildings. Those buildings have a large array of objects that are in almost all of them. Such arrays include doors, floors, furniture, and windows. Specifically, windows have mechanisms to restrict the light flow through them. Such mechanism (or object) could be a cloth drape, wooden panel, blinds, or any opaque object that prevents light from getting through into a room or building. These objects usually have (unless they are broken) an operation which will change the position of the object to either allow light to enter the room, or to block it out. This operation requires, to some extent, physical interaction by an end user. This interaction entails several things. First interaction involves the end user having to touch the object or mechanism. Proceeding that, the end user must inject physical energy into the system since that is the expected source of energy for the given mechanism for a window.

Now our project is to automate this process or interaction. This will remove the need for physical interaction from the perspective of the end user. This way, the end user could have a seemingly infinite number of ways to perform this operation without physically interacting with the system. They could, for instance flip a switch, ask Alexa to do it, or even trigger some sort of proximity sensor. This will be accomplished using an embedded computer handling the operation of making light pass through the window, or block light from passing through the window into a room or building. Now, this is a simple task. The creation of this project will not lead to the creation of some incredible new technology. However, there is one extremely important detail to this idea. It is that virtually everyone in America could be an end user of this project. Even though this is a fairly simple idea, the latent ability for the reach of this project is endless because of the previous stated fact.

Another benefit of this idea, and why it has such great reach, is its customizability. By having a short five-minute discussion with a window manufacturer, the idea of a single type of window being used in a ton of applications is far-fetched due to several factors. The first reason is that there isn't a standard window size. This leads to a ton of different windows in use with a wide variety of form factors. In addition to that, you also must consider that there is a wide variety of specific use cases and conditions that different end users will want. Certain end users will place high value on aesthetic appeal (just take one look at Apple). Other end users will value the cost effectiveness of the unit. Other end users will place the highest value on the number of useful functionalities.

So, in conclusion, at its core, our project idea is a simple idea of automating the process of interacting with a window. However, despite that, it has incredible potential to reach an astronomically large pool of end users. If we employ effective planning and design techniques to reach this goal, the applications of this project are seemingly infinite.

Requirement Specifications

Table 1: Requirement Specifications Summary

Description	Value	Unit
Activation method	3	ways
Opaqueness	≥ 90	%
*Cost	≤ 600	$
Power consumption	≤ 10	W
Activation range	≤ 50	cm
Transparency	≤ 10	%
*Time to activate	≤ 10	seconds
Efficiency	≥ 90	%
*Changing opaqueness	≥ 10 and ≤ 90	%

*3 specifications to be demonstrated

Cost

The goal of the group is to implement a cheap but productive device that can satisfy all the engineering requirements with less than 600 U.S. dollars. The target budget is set out low because of the modern technology, there are many electronics equipment from different companies/suppliers can help drive the cost for the project down.

Time to activate

The time to activate the device is set to be 10 seconds for now although the status of the PDLC film changes quickly where it only takes half a second. However, our group hope we can improve the actual time to activate the device to be less than 3 seconds where the sensor senses the analog signal. The analog signal then can be converted to digital signal and sent to the MCU for data processing.

Changing opaqueness

The transparency of the PDLC film is less than 10% which is clear, and more than 90% which is opaque. Our group hope we can manipulate the voltage usage for the PDLC film to change the percentage of transparency for variety applications.

Efficiency

Due to many applications of the project such as blocking sun lights, view sightings when needed, etc. the efficiency can be set at 90% where 10% error is acceptable.

Power consumption

The PDLC film uses AC voltage with low voltage from 35-65 VAC or it can be used with a 12 VDC power source with a current of 0.08 A/m^2 which the maximum power usage for the film alone to be around $5W/m^2$. The power for the film combines with other components of the project would not exceed 20W.

Activation methods

Our group discusses about the activation methods and we come up with 3 ways:

1. Switch: this is the simplest form of how to activate the device. A flip from a switch can turn the film on or off.
2. Human presence: for this method, an adult needs to be presence in front of the proximity sensor within the range so the signal can be picked up to activate the device.
3. Digital application interface: almost everything is accessible through our phones now, therefore, a handy app in a phone to control the PDLC film is necessary for this project.

Activation range

For view sightings, a user needs to be close to the windows where the view can be captured completely by the eyesight. Therefore, we set the range to activate the PDLC film to be round less than 50 cm. Nevertheless, what if the user wants to activate the device with a further range? The answer is from the other 2 methods where the switch and the phone app will be applicable.

Possible Project constraints

The technology that will be used for the design is called Polymer Dispersing Liquid Crystal (PDLC) film or switching film. This material currently is on the more expensive side when compared to Conventional blinds. Another constraint is ensuring that the inputs and outputs of the blinds (on/ off) are readable to the microcontroller used for designing the system for the electronic blinds. Another constraint will be ensuring that the pee strips can be powered with the relevant power source whether that be a solar panel or a hard wire into a plug. Another constraint will be sourcing all of these materials needed to build the design system with a global pandemic going on. Currently one year into this global pandemic Supply chains are still disrupted. Ensuring that the PCB, microcontroller, solar panel, PDLC film, and miscellaneous components arrive on time will be crucial in completing this project. Along with this, learning on the go how to interface these different components to achieve the goal of this project will be essential.

Technology

Depending on the technology we decide to implement we can run into various drawbacks. For example, electric chromatic SmartGlass are two panes of glass with a smart film in between them specifically microscopically thin electric chromatic material [2]. A safety concern from this arises that if the glass is cracked or if the material in between is exposed the user maybe shots or the system may stop working entirely. Along with this ESG has a very long transfer time.

Energy

Heating- it will be important to check to see if our system design has a satisfactory u-factor as deemed by the US Department of energy. The U-factor is defined by defenestration of the window. “The U-factor is a measure of the rate of heat flow through glazing products; the lower a U-factor, the less heat will flow through the window. In the United States, U-factors are reported in Btu/(h·ft2·°F), and typically range between 0.2 to 1.2 Btu/(h·ft2·°F).” [1]

WINDOWS

CLIMATE ZONE	U-FACTOR[1]	SHGC[2]	
Northern	≤0.27	Any	Prescriptive
	=0.28	≥0.32	Equivalent Energy Performance
	=0.29	≥0.37	
	=0.30	≥0.42	
North Central	≤ 0.30	≤ 0.40	
South Central	≤ 0.30	≤ 0.25	
Southern	≤ 0.40	≤ 0.25	

SKYLIGHTS

CLIMATE ZONE	U-FACTOR[1]	SHGC[2]
Northern	≤ 0.50	Any
North Central	≤ 0.53	≤ 0.35
South Central	≤ 0.53	≤ 0.28
Southern	≤ 0.60	≤ 0.28

Air Leakage ≤ 0.3 cfm/ft2

1 Btu/h ft2·°F
2 Solar Heat Gain Coefficient

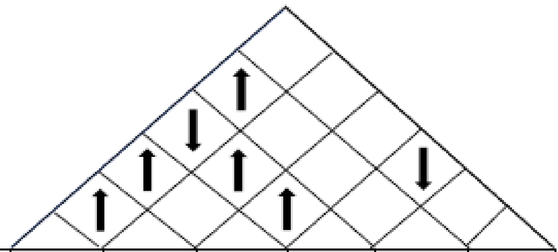
Figure 1: Performance criteria for windows and skylights based on ratings certified by the National Fenestration Rating Council (NFRC)

To maximize energy savings, we should follow the standard set by the department of energy they suggest that your product have a low solar heat gain coefficient or SGHC. They also recommend having tints of some kind, with this project we should be able to meet both recommendations. If in the future our product is determined to me energy star ratings the users will be able to qualify for rebate from certain utilities for having these products, on top of the savings in energy. Along with measuring the SHGC we should also measure the visible transmittance also known as VT. This is the amount of visible spectrum or light that passes through a glazing unit is usually the values range between 0 and 1, with below .5 being a noticeable reduction in the amount of light transmitted. With our unit we should be able to vary the visible transmittance depending on the opaqueness setting currently enabled. Our goal should be to be within the recommended range for the Southern Region of the US [1, 2]

Economic

Manufacturing these units in mass will surely reduce the price. However, producing the prototype may prove expensive. Buying the device for the transparent/opaque feature could prove expensive. On top of that we will have to have it interface with our own PCB, possible relays and power supply which may require specific components. Additional research will be required to satisfy these concerns.

House of Quality



Marketing Requirements	Polarities	Power Consumption	Accuracy	Time Response	Cost	Idle Time	Board Dimension
		-	+	-	-	-	-
1. Safety	+				↓↓		
2. Cost	-	↓					↓
3. Reliability	+		↑↑				
4. Ease of use	+				↓		
5. Performance	+		↑↑	↑↑		↑	
6. Power Consumption	-	↓				↑↑	
Targets for Engineering Requirements		< 20 Watts	≤ 150 cm	≤ 5 seconds	< $1000	≤ 5 minutes	≤ 4" x4 "

Polarity	
Positive	+
Negative	-

Correlations	
Strongly Positive	↑↑
Positive	↑
Neutral	
Negative	↓
Strongly Negative	↓↓

Figure 2: House of Quality for Electric Blind

Block Diagram

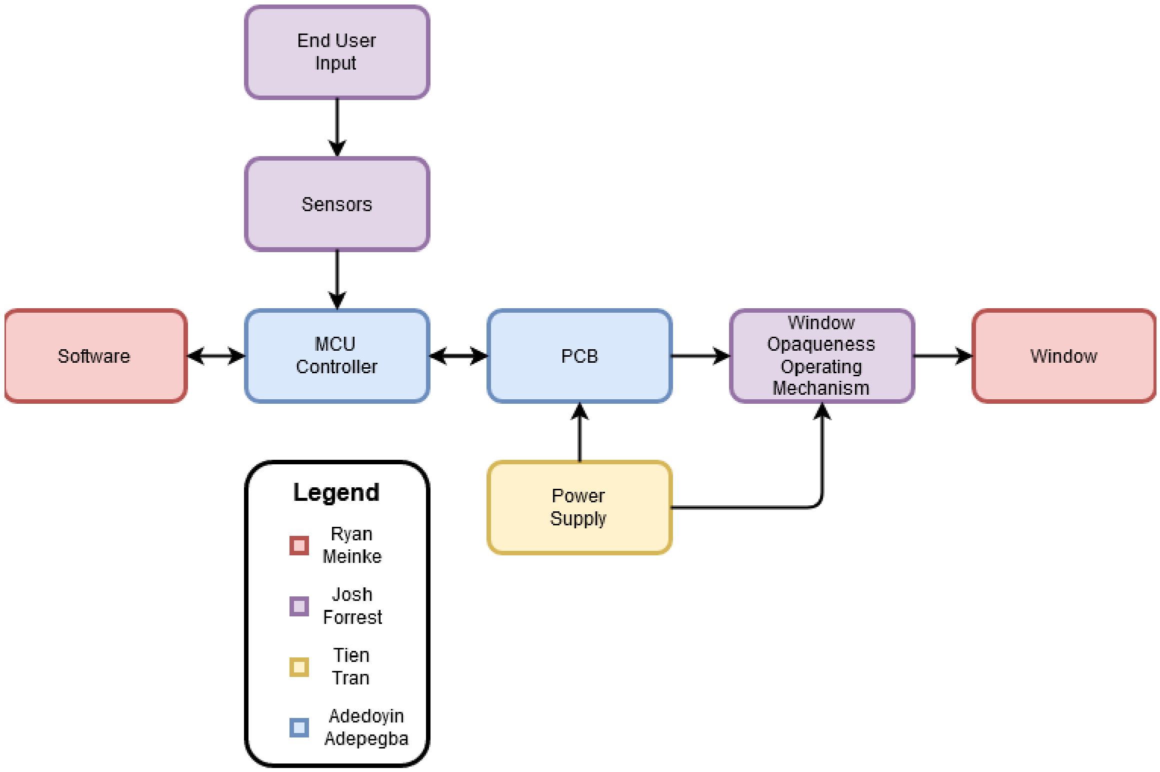


Figure 3: Hardware and Software Block Diagram for Electric Blind

Budget and Funding

In the budget estimate of this project, you can see that we are estimated to spend around $450. However, this is a generous estimation. We believe we can get the PDLC film cheaper, if we decide to go this method, another example is the PCB. As this will be our first time generating our own PCB and we are not sure with the exact components, we will need we decided to go with an inflated cost on the fabrication cost, which also includes the parts for set fabrication. At the end of our chart, there is an additional feature total. We decided to add this so that we would have an estimate of what it would cost to add these additional features. We plan to split the cost of this project equally four ways with each member having to agree on the components before we decide to pay. There will be a document to track all the suggested options, so we have a record on what was chosen and why.

Table 2: Estimated Budget using information from [3, 4]

Component	**Cost**
PDLC film	$150
PCB	$150
Controller	$50
Proximity sensor	$15
Solid State Relay	$15
Miscellaneous (wires, frame, etc.)	$70
Total	$450
Solar panel	*$150*
Additional Feature Total	*$600*

Project Milestones

Table 3: Senior Design 1 Milestones

Milestone	Description	Duration	Dates
Group Formation & Project Selection	Divide and Conquer v1	3 weeks	Jan. 18 – Feb. 5
	Divide and Conquer v2	1 week	Feb. 6 – Feb.12
Document Submission: Initial Group and Project Identification (Divide and Conquer v1)			Feb. 5
Document Submission: Divide and Conquer v2			Feb. 12
Technology Investigation	Hardware: - Power Supply - PCB Design - Sensors selection Software	3 weeks	Feb. 13 – Mar. 5
60 Page Draft	Divide and Conquer v2 Revision	4 weeks	Mar. 6 – Apr. 2
Document Submission: 60 Page Draft			Apr. 2
100 Page Report	60 Page draft Revision	2 weeks	Apr. 2 – Apr. 16
Document Submission: 100 Page Report			Apr. 16
Final Document	100 Page Revision	1 week	Apr. 16 – Apr. 27
Document Submission: Final Document			Apr. 27
Components Acquisition	Order parts and components - Initial component testing		

Table 4: Senior Design 2 Milestones

Milestone	Description	Duration	Dates
Prototyping	Initial Prototyping	2 weeks	May 1 – May 14
	Complete Prototype Ready for testing and Debugging	2 weeks	May 14 – May 31
Testing and Debugging - Test components - Debug outputs		4 weeks	April
Finalize Project - Final testing and debugging - Demo Creation		4 weeks	May
Peer Presentation		TBD	June
Final Project Documentation - Create Final Presentation		TBD	July
Final Presentation		TBD	August

References

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[3] “Proximity Sensor.” https://www.amazon.com/Arduino-Proximity-Sensor/s?k=Arduino+Proximity+Sensor

[4] “Solid State Relays.” https://www.amazon.com/Solid-State-Relays/b?ie=UTF8&node=6374820011