LIGHT SENSING AUTOMATED BLINDS

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Abstract

This project is solving the problem of wasted energy within buildings and homes, because currently the lights turned on inside building do not utilize natural, ambient light from the sun. Rather than having unnecessary light from a light source, the automated light sensing smart blinds can sense the amount of light outside the window and in the room, and then adjust the angle of the blinds to save energy by utilizing the available outdoor light. This way, the light source will not be running at maximum power output while there is excess light coming through the window. This project aims to design and construct the light sensing blinds to achieve the aforementioned goals. Hardware test results from this project demonstrate the capabilities of the smart blind system to measure ambient light inside the room and outside the window, to adjust the angle of each of the blinds on the window, and to change the desired brightness of the room.

Chapter 1. Introduction

Over the past 15 years, the world's energy consumption has grown at an alarming rate. Per a statistical review by BP (British Petroleum), in terms of millions of tones oil equivalent, the worlds consumption has gone up from about 8,500 to over 13,000 as shown in Figure 1-1 [1].

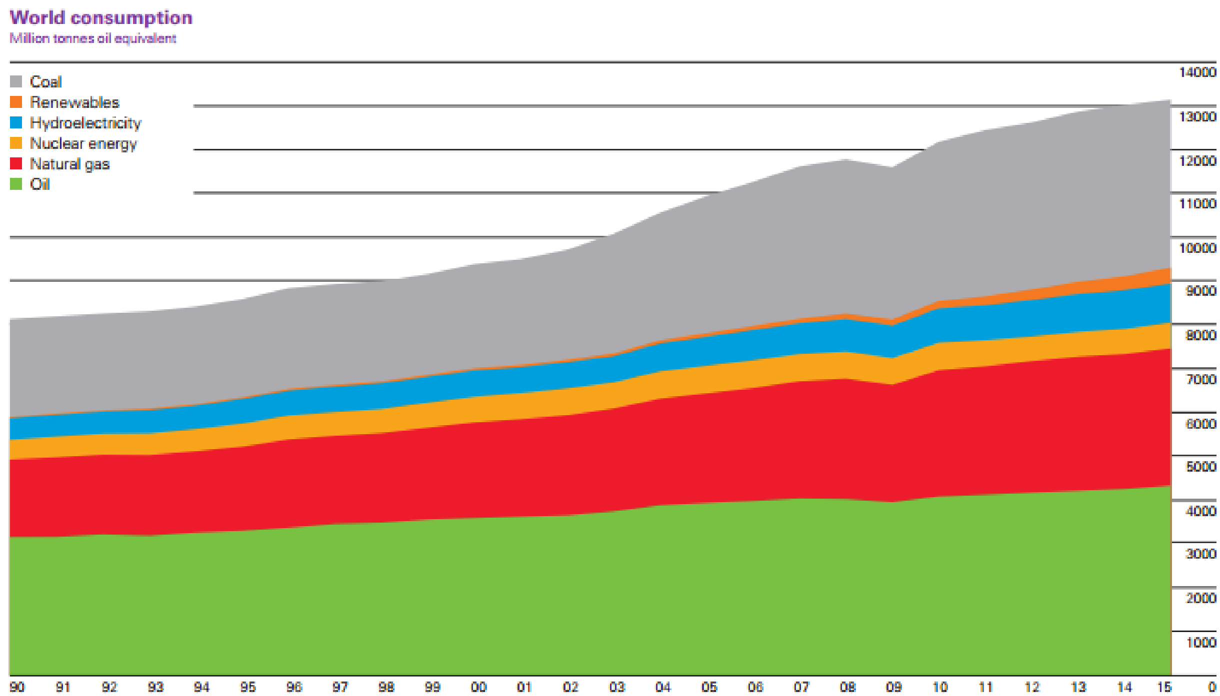

Figure 1-1. World Consumption of Energy, 1990-2015 [1]

The problem is that many of the energy sources shown in Figure 1-1 are non-renewable, meaning that these sources will run out or not be replenished in our lifetimes. These sources include coal, oil, and natural gas, which are the three largest sources of energy consumed world-wide [2]. If these sources will not be replenished in our lifetime, that means our consumption rate is greater than our supply rate, which will result in these sources eventually being used up. This is why energy consumption reduction has become increasingly important, in order to guarantee that we will have enough energy to support life in the future. Although renewable energy sources have become more widely used, the best way to reduce use of non-renewable energy sources is to reduce energy consumption.

Due to this concern, many emerging and innovative technologies have gained consumer support over the past 15 years. Some of these innovations include advanced manufacturing, LED lighting, electric vehicles, and solar technologies. Especially in terms of solar technologies, global production has been increasing 30% over the last 30 years, with prices falling nearly 10% year [3]. The energy efficiency and manufacturing improvements for this technology have enabled their increase in production, which has helped dramatically with reducing use of non-renewable resources. LED lighting on the other hand is one way to reduce energy consumption in general, as they use 80% less energy than halogen bulbs and 25% less energy than CFL's [3]. Home improvements are a big way humanity is attempting to do to reduce energy consumption, whether that be through LED lighting, or innovative building design.

For home innovations, the focus has been on new energy efficient improvements like better housing frame designs, cool roofs, and solar panels. Advanced housing frames reduce the lumber use and waste with a wood-framed house. Cool roofs use reflective materials to reflect more light and absorb less heat from sunlight. Solar panels on roof-top maximize the amount of sunlight hitting them every day, which in turn provides energy for the house [4]. These technologies are important because of the benefit they offer home consumers in reducing energy usage and thus energy cost. One such technology that achieves this goal is the smart blinds system.

Chapter 2. Background

The Problem

As sustainability has come to the forefront of modern technology, people are continually looking for ways to be more sustainable in their everyday lives. The field of smart-home technology fits into the homeowner's attempt to become more sustainable. Ranging from solar panels to thermostats, people are continually finding new ways to advance this technology. This is where the idea for automated blinds comes into play. As another way for homeowners to be more sustainable and save money, automated blinds will allow homeowners to save energy, and money, by not having to manually control their lights and blinds [5].

Homeowners waste energy by leaving lights on and blinds closed throughout the day, when there is plenty of natural light for them to take advantage and to keep the necessary amount of light in the room. The proposed smart blinds will work along with a light switch set the desired amount of light in the room, while automatically adjusting the blinds to sustain the amount of light; therefore, saving the homeowner money and energy.

Background

Household window blinds have been in use for many years now, with the first blinds being used by the early Egyptians and Chinese. The Egyptians chose to string reeds together to form blinds, while the Chinese strung together bamboo (Figure 2-1) in order to keep people safe from the sun. The next big blinds came when the Persians introduced blinds to Venice, which is where the term "Venetian" blinds started. An Englishman named Edward Bevan was award the first patent for Venetian blinds in 1769, using wooden slats. By placing this slats in a frame and manipulating the slats, he discovered you could allow a certain amount of light into a room. John

Hampson of New Orleans added the ability to change the angle of the horizontal slats in 1841, which are very similar to the ones still in use today [6]. Hunter Douglas was the first company to develop a light, aluminum Venetian blind in 1946. Other notable improvements include the use of motors to automatically control the blinds rolling up and/or changing the angle. As shown in Figure 2-2, more popular motorized blinds include a screen that is being controlled to let in sunlight, although motorized venetian blinds are also available as shown in Figure 2-3 [7].

Figure 2-1. Bamboo Window Blinds

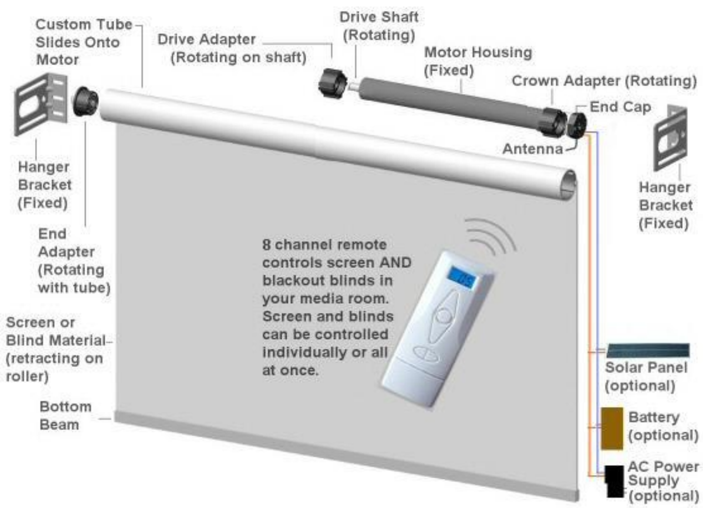

Figure 2-2. Motorized Blinds Controlling a Screen

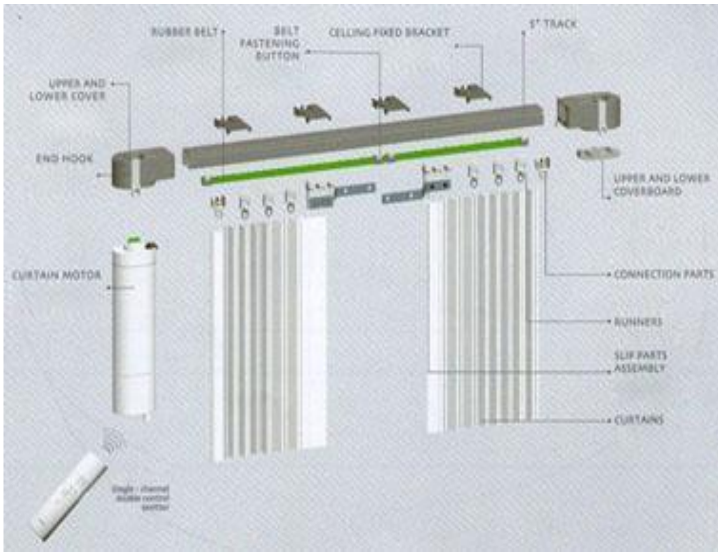

Figure 2-3. Motorized Venetian Blinds

The original push for motorized blinds was more closely related to a desire for ease of use for homeowners, allowing them to control the blinds with their smartphone or a remote, rather than manually adjusting the blinds. This design has since transformed into a piece of the home sustainability market, as new products have been developed to turn this system into a money-saving technology.

Related Projects

There are only a few present solutions that are currently available on the market, although no solutions sell the full system of the blinds with the light sensing devices. The first market solution is through a company called RollerTrol™ which sells the sunlight sensor for the blinds system. The first disadvantage of this solution is that the user must manually configure and install the sensor with their motorized blinds, which might be difficult and tedious for the average consumer [8]. The other disadvantage is that the motors and blinds are not included with their design, which makes integration of components potentially more difficult. The next competitor is somfy®, Sunis Indoor Wirefree™ RTS Sun Sensor, which is also selling just the sunlight sensor for the blinds system. The difference between somfy® and RollerTrol™ is that a company called Budget Blinds Corporate is offering to install the somfy® sun sensor with the customer’s motorized blinds [9]. This is beneficial because the customer does not need to have a technical background in order for the blinds to be installed. The disadvantage is that this product again assumes the customer already has motorized blinds installed, and now adds the cost of labor for installing the new, sun sensor. Our solution addresses this problem by providing the whole system to the customer, so that the integration of parts is very easy, the customer will not have to pay twice for labor, and the sunlight outside of the window is taken into account to make sure the sunlight readings are accurate enough.

Design Objectives

The design we are striving for will incorporate ideas from these previous projects and improve upon them. By incorporating a second sensor inside the room, our blinds will be able to compare the light inside and outside of the room, compare them, adjust the indoor lighting, and adjust the blinds to have a comfortable amount of light in the room. The next design improvement that our system will have over these competitor designs is that the entire system (blinds, sensor, microcontroller, etc.) will all be included in the system, rather than requiring the user to piece them together on their own. Lastly, with a basic knowledge of microcontroller coding, the user will have the ability to adjust the amount of light that they view as a “comfortable” level. The overall objective of our project is therefore to design a system that will save energy and money by incorporating indoor lighting and automated blinds to give the homeowner a comfortable amount of light in their homes.

Chapter 3. Design Requirements

Block Diagrams

The level 0 block diagram for this light sensing, smart blinds system is shown in Figure 3-1. There are 4 inputs (the light intensity inside the room, the light intensity outside the room coming through the window, the user desired light intensity inside the room, and power from the wall outlet at 48 V DC) and 1 output controlling the amount the blinds will open for this system.

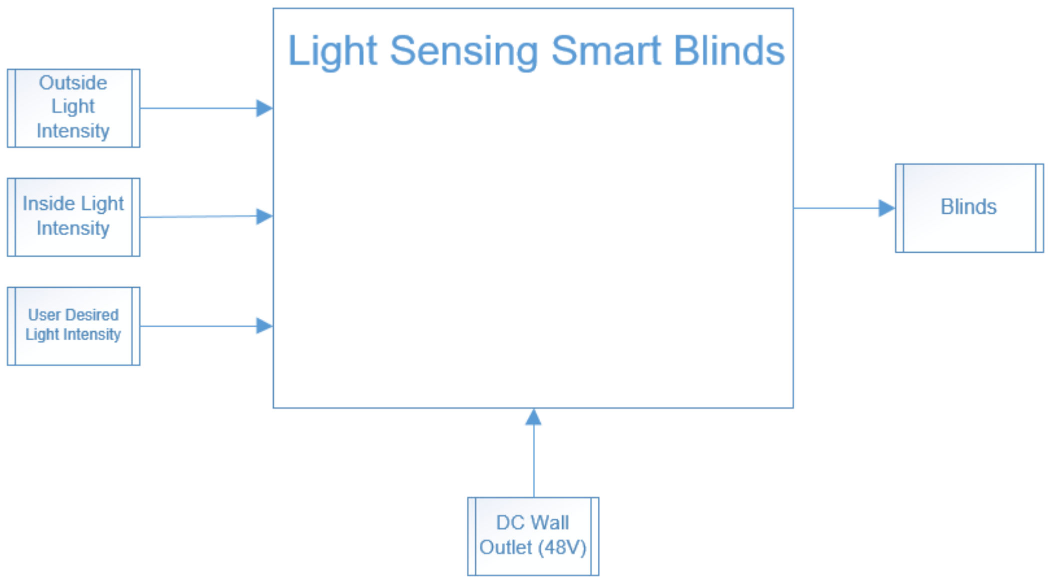

Figure 3-1. Level 0 Block Diagram

The level 1 block diagram for this light sensing, smart blinds system is shown in Figure 3-2. Inside the entire system, there are 7 subsystems. Two of the subsystems will be photoresistors, used to measure the intensity of light inside and outside the room. The light switch is another subsystem which is adjusted by the user to set his/her desired light intensity level inside the room. The wall outlet power goes to the converter subsystem, which will convert the 48V DC to 5V DC for the microcontroller to be powered. This converter subsystem will consist of a buck step down DC-DC converter. The microcontroller subsystem will take 4 inputs (from the photoresistors, the light switch, and the DC-DC step-down converter) and produce 1 output. The microcontroller will first take in the user desired light intensity level, and compare this to the light intensity outside the room. If the desired light intensity level is lower than the light intensity outside the room, the microcontroller will send a signal to the motors' subsystem to close the blinds in order to decrease the amount of light coming in the room. If the desired light intensity level is higher than the light intensity outside the room, the microcontroller will send a signal to the motors to open the blinds to allow the maximum amount of light in the room.

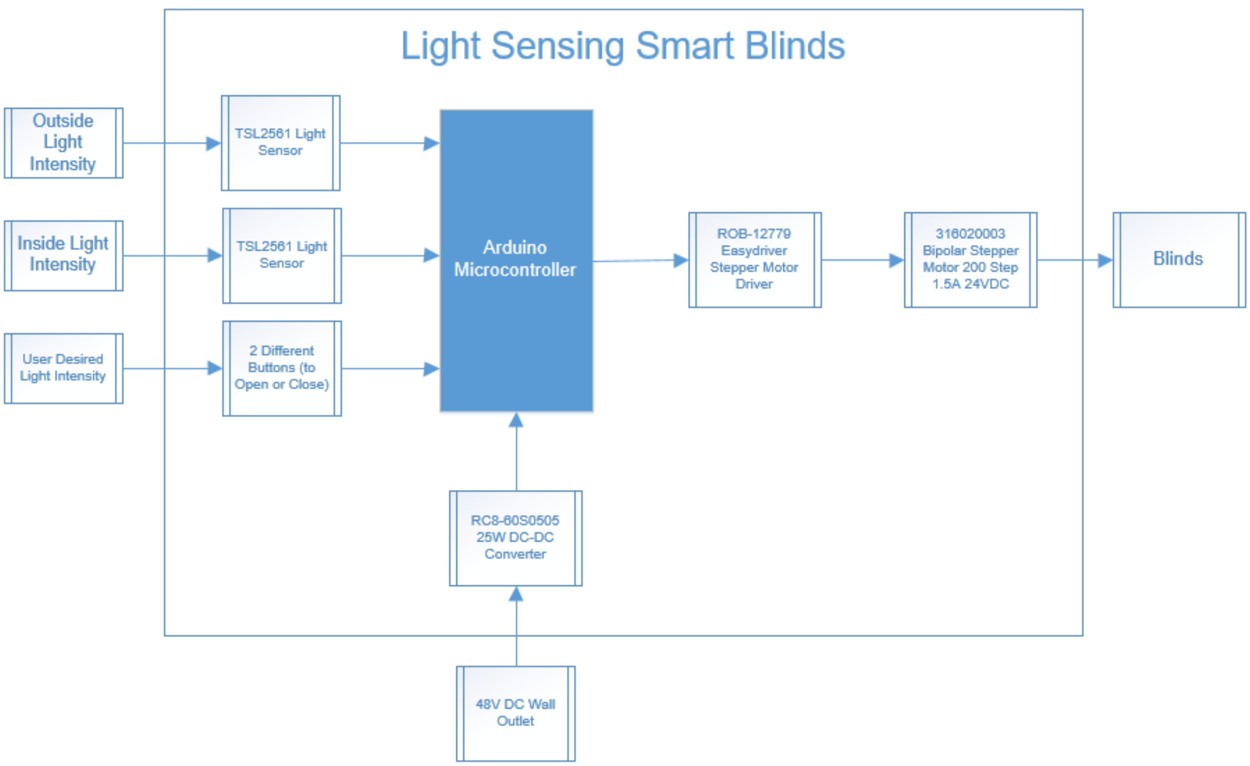

Figure 3-2. Level 1 Block Diagram

Design Requirements

The focus for the design requirements of this project is on making the system as user friendly as possible. First, the system must be fully autonomous. Once the user adjusts the light switch to the level they want, the system must adjust the opening of the blinds without further user interaction. Next, the system must sense indoor and outdoor light. Unlike existing systems that either sense indoor or outdoor lighting, our system will sense both to determine the necessary amount of indoor/outdoor lighting to have in the room. The blinds will be controlled with a stepper motor programmed through a stepper motor breakout board and an Arduino interface, allowing for the microcontroller to adjust the blinds as necessary. The Arduino will compare the indoor and outdoor lighting to determine how much indoor light is necessary and how much the blinds must be open to match the user's desired amount of light in the room. The system must be cost effective. This requirement is important because the idea behind this project is to fit into the smart home technology field; therefore, the system must work autonomously to save the customer money and energy once this system is installed. Lastly, the other customer requirement is that the system keeps the desired amount of light in the room at all times, allowing the customer a comfortable level of light that is up to their choosing. These specifications are summarized in Table 3-1.

As far as measurable project specifications go, the only limits this project has are the size of the window being used for test/demonstration, being able to use an input voltage of 120Vrms (AC) or 48V (DC), and the stepper motors having enough torque to smoothly move the blinds without any trouble. This window, in the DC shed, was measured to be 23" x 23", however, it would be simple to adjust the system for a larger window. This would only require getting larger blinds. Besides the size of the window, the rest of the system will consist of the Arduino, a small circuit board, and the plug for the wall outlet. The Arduino and circuit board will not require a lot of space and will be easily housed in a small box, taking up minimal space. The blinds used will also be very light, to reduce the torque needed by the stepper motor, to make the necessary motor cheaper. Table 3-1 summarizes the design requirements for the proposed smart blinds.

Table 3-1. Design Requirements

Requirement Number	Requirement Name	Justification
1	Fully Autonomous	What sets our system apart is the fact that it will be fully autonomous and require no user interaction once it is plugged into a wall outlet, making it more user-friendly.
2	Senses Indoor/Outdoor Light	The next key feature is that it will read and evaluate both the indoor light levels and outdoor light levels.
3	Controls Blinds with Motor	The blinds will be controlled with a stepper motor programmed through the Arduino interface.
4	Compares Indoor and Outdoor Light	Comparing the indoor and outdoor light will allow the system to control the blinds to keep the desired light level.
5	Cost Effective	The key to this system attracting customers will be its ability to save the user money on their monthly power bill, so it’s important that the system work autonomously without using too much power.
6	Allows Comfortable Amount of Light into the Room	Along with saving money, the system must keep the room comfortable for the customer by allowing a desired amount of light, set by the user.

Chapter 4. Design and Simulation Results

Design Results

In Chapter 3, the design requirements for the project were listed, and an explanation was given as to why they are important. This chapter will show what parts we picked to address these requirements and why they were chosen. The requirements were as follows: fully autonomous, senses indoor and outdoor light, controls the blinds with a motor, compares indoor and outdoor light, cost effective, and that the system maintain a comfortable amount of light in the room.

First, to make the system fully autonomous, the design uses an Arduino Uno Microcontroller to sense the light and control the motors. This will allow for the system to run at any time the Arduino has power, allowing minimal interaction with the system from its user. Next, to allow the system to sense indoor and outdoor light, we purchased two TSL2561 Light sensors from Adafruit. These sensors were chosen for three main reasons. First, the fact that this product interfaces well with the microcontroller being used. Second, the sensor can detect light ranges from 0.1 - 40,000 Lux at high speeds, which is more than enough for this application. Third, the sensor is low power, drawing less than 0.5mA when in use, increasing the efficiency of our system.

When designing how to control the motor, we picked a cost-effective stepper motor driver that would make control of the stepper motor easy, and would take an input of 5V from the Arduino. The stepper motor chosen is small and rated for the output voltage of the stepper motor driver. The components we decided on are the ROB-12779 Easydriver Stepper Motor Driver and the 316020003 Bipolar Stepper Motor 200 Step 1.5A 24VDC. After soldering a header to the stepper motor driver, we could then solder the 4 wires from the stepper motor directly to the driver. To control the stepper motors using the driver, the step and direction pins of the driver are connected to the Arduino. With these pins, we can adjust the speed of the motor, and equate that to a desired distance using the following equations.

$$mDelay = \frac{stepDist * 100{,}000}{2 * stepRev * speed} \quad (4\text{-}1)$$

To control the motor movement, the step pin must alternate between high and low, with a delay between changing the pin. mDelay is therefore calculate, based on the distance per step (60 microns/step), the steps per revolution (200 steps/rev), and the speed (rpm). Based on the user input for speed, the motors would then rotate at the correct rpm.

$$steps = \frac{mDist}{stepDist} \quad (4\text{-}2)$$

To control the distance the motor moved horizontally, we had to convert to steps for the stepper motor. By dividing the user desired distance by the distance per step of the motor (60 microns/step), the stepper motor would move the correct distance.

To address the requirements of comparing indoor/outdoor light levels, the code will be written in a way that will take in the light intensity both inside and outside the room, and if more outdoor light is available and the indoor light intensity is lower than desired, the blinds will be adjusted. This way, a comfortable amount of light will be present in the room at all times. Another addition to the system that will help control the amount of light in the system will be a two-button user interface, operating similar to a light dimmer switch, that will allow the user to essentially turn up or down their desired light level. This value will be read into the microcontroller along with the outdoor and indoor light levels to allow the user to control how much light they want to be let in the room.

Other design considerations that we took into account were cost effectiveness and operating from a 48VDC supply. The microcontroller operates from a 5V voltage input, so we needed a 48V to 5V step-down converter. The converter we went with is the RC8-60S0505. This converter can step-down a voltage of anywhere from 8-60V down to 5V with <1% error. Also, this converter operates at about a 94% efficiency. Lastly, to address cost effectiveness, the price of each component used was taken into account, The total price for each component in the system came out to less than $100, making the system relatively cheap as far as its competitors go. Figure 4-1 shows a more detailed version of our block diagram with part names and numbers included.

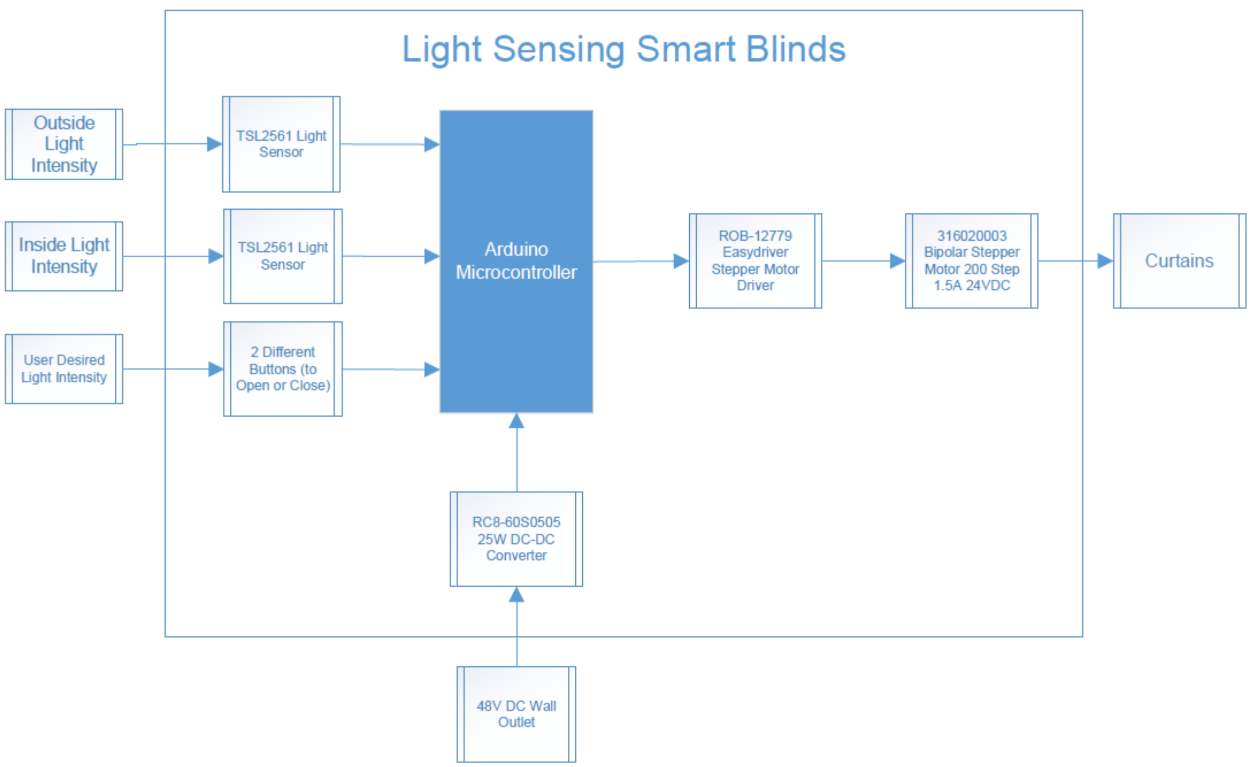

Figure 4-1. Designed Level 1 Block Diagram

Existing Technology

There are only a few present solutions that are currently on the market, although no solutions sell the full system of the blinds with the light sensing devices. The first market solution is through a company called RollerTrol™ which sells the sunlight sensor for the blinds system. The first disadvantage of this solution is that the user must manually configure and install the sensor with their motorized blinds, which might be difficult and tedious for the average consumer. The other disadvantage is that the motors and blinds are not included with their design, which makes integration of components potentially more difficult. The next competitor is somfy®, Sunis Indoor Wirefree™ RTS Sun Sensor, which is also selling just the sunlight sensor for the blinds system. The difference between somfy® and RollerTrol™ is that a company called Budget Blinds Corporate is offering to install the somfy® sun sensor with the customer's motorized blinds. This is beneficial because the customer does not need to have a technical background in order for the blinds to be installed. The disadvantage is that this product again assumes the customer already has motorized blinds installed, and now adds the cost of labor for installing the new, sun sensor. Our solution addresses this problem by providing the whole system to the customer, so the: integration of parts is very easy, the customer will not have to pay twice for labor, and we take into account the sunlight outside of the window to make sure the sunlight readings are accurate enough.

Chapter 5. Hardware Test and Results

Hardware Setup and Testing

In Chapter 4, the design requirements for our automated blinds system were presented. Chapter 5 will outline how these requirements were addressed and built. To begin, the device was powered from a DC Power Supply set to provide a 48V input to the DC-DC Converter. The converter produced an output of about 5V within a 1% error. The converter was tested by first plugging it into the DC Power supply with no load attached on the output wires. This produced a steady output around 5.03V. Over the entire rated range of the converter (8-60V), the output voltage was steady between 5.03V and 5.05V. The final step was to connect a load, which in this case was the Arduino to check if the Arduino would turn on. This was able to power the Arduino, and therefore drive the system. A picture of the power supply is shown in Figure 5-1.

Figure 5-1. SMAKN DC-DC Converter

Once the system was powered, the next step was to construct the rest of the motor control, light sensor, Arduino, and blinds system. Taking into account that the system was to be placed in the DC Shed on a window of about 2’x2’ with about a 4” window ledge, we decided to use the ledge to support the hardware by attaching a bracket to it. In order to test the system prior to installing it, the blinds were placed on a piece of plywood used to simulate the window. The Arduino and proto-board housing the motor driver and indoor light sensor will then be placed behind the blinds on the window ledge. The other light sensor, for the outdoor lights, was soldered with long wires so it could sit behind the blinds, facing outwards, above the window ledge. The motor will be mounted behind the blinds as well using a mount system that was purchased with the motor. This allows the motor to be mounted closer to the top of the blinds where we needed to be able to open and close the blinds. We decided to go with a blinds system, rather than curtains, because would be able to better diffuse light into the room, rather than the room being very bright in some parts of the room, while being very dark in others. The light sensor used is shown in Figure 5-2.

Figure 5-2. Light Sensor

To test the light sensor, four connections were made to the Arduino: Vin to 5V, GND to GND, SDA to A4, and SCL to A5. By using the Arduino library Adafruit_Sensor.h and Adafruit_TSL2561_U.h, the sensor could be configured and displayed the light level readings (in lux) in the serial monitor. After opening the serial monitor and seeing lux values within a typical range (about 0-100,000 lux), we confirmed that the light sensor operated correctly. To connect a second light sensor later in the project so that we could have one light sensor outside the room and one inside the room, the connections were made to the same pins except the ADDR of this sensor was connected to GND. By doing this, the new sensor had a different address than the first sensor, and both sensors would then be able to communicate on the same bus with the Arduino.

The next phase of our hardware setup was laying out and soldering the proto-board and the components it needed to house. First, simple Arduino code was written to verify the light sensors, stepper motor, stepper motor driver, Arduino, and buttons worked correctly, which was done by wiring on a breadboard. The stepper motor driver is shown in Figure 5-3, and the stepper motor is shown in Figure 5-4.

Figure 5-3. Stepper Motor Driver

Figure 5-4. Bipolar Stepper Motor

The stepper motor driver and was tested by connecting the: 5V and M+ pins to the 5V output on the Arduino, GND pins to GND on the Arduino, and enable, step and direction pins to pins 10, 11, and 12 respectively on the Arduino. The stepper motor has 4 wires protruding from it (green, black, blue and red), and by comparing to the datasheet, the wires were connected to the driver with green in position A1, black in position A2, blue in position B1, and red in position B2. By using Equations 4-1 and 4-2 to calculate the delay and number of steps desired by the user, we made the motor work by toggling step pin HIGH and LOW with this delay in between, which will rotate the armature inside the motor. A snippet of the code used is shown in Figure 5-5.

```
void openBlinds(){
  digitalWrite(enablePin, LOW);  //enable the driver
  delayMicroseconds(2);
  digitalWrite(dirPin, LOW);
  for(int i=0; i<=steps; i++) {
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(mDelay);
    digitalWrite(stepPin, LOW);
    delayMicroseconds(mDelay);
  }
  digitalWrite(enablePin, HIGH);
  delayMicroseconds(2);
}
```

Figure 5-5. Arduino Code to Open the Blinds

Then the wires were soldered onto the proto-board, so they could sit underneath the motor driver board and the indoor light sensor, keeping the board organized and clean. After soldering the light sensors, button, and stepper motor driver to the proto-board, the system was tested by affirming the buttons, motors, and light sensors still operated properly, as they did on the breadboard. Once the functionality was proven to be the same, the proto-board was reconnected to the Arduino and motor for installation in the system. The Arduino code did not require much testing, aside from confirming that integrating the stepper motor with the light sensor and buttons worked. Integrating these 3 components went smoothly and was completed, with the only mistake corrected being one ground wire on one of the light sensors being mistakenly connected to the 5V pin.

Controlling the blinds system proved to more difficult than anticipated and required us to "hack" into the blinds bought from Home Depot to control it. To do this, we took out the tilt wand and associated plastic that locked the rotating bar inside the blinds, giving us the availability to open and close the blinds without turning the tilt wand. To open and close the blinds, we first tried using a loop of fishing line attached to the strings connecting the blinds system and around the motor via a pulley, which would rotate each slat. The next problem encountered was gaining enough traction on the pulley with the fishing line. This was addressed by looping the line around the pulley and tying some extra knots onto the line to get more traction. Because this still did not work as effectively as we had hoped, we decided to break off some of the plastic on the blinds and attach a pulley directly to the rotating, horizontal bar that rotates each slat. By doing this, we now incorporated two pulleys into our design and no fishing line. By attaching a rubber band to connect both pulleys, the motor can be used to effectively rotate each slat on the blinds.

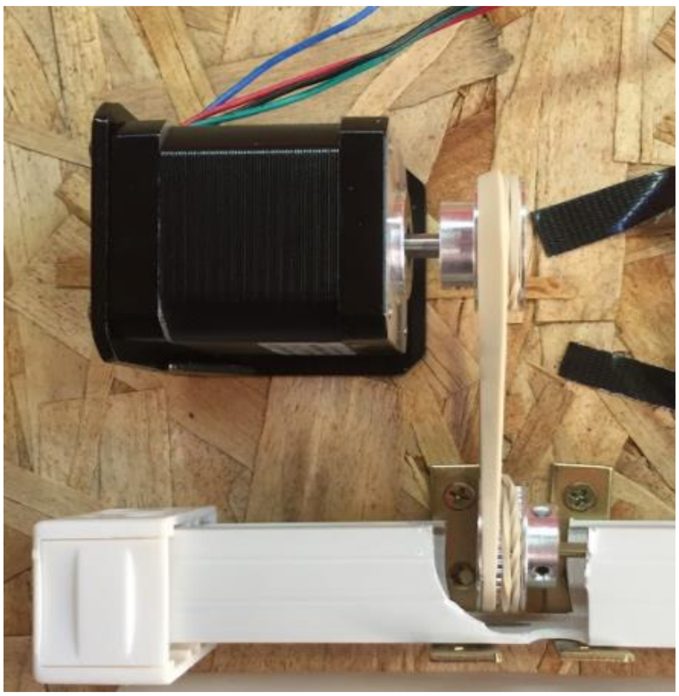

Figure 5-6. Blind Control System

Figure 5-6 displays the control system outlined in the previous paragraph. At the bottom of the image, you can see where the blinds were cut to allow the pulley enough room to spin. The bottom pulley is attached to bar to rotate the blinds. Unfortunately, after the blinds were cut, they were too weak to support the weight, so two angle brackets were installed to solve that issue. As mentioned before, one of the largest issued we faced was gaining traction on the pulleys. The rubber bands were much better than the fishing line, but were still not perfect. Therefore, each pulley was wrapped with a smaller rubber band, so the larger one had enough traction through the full range of motion necessary to move the blinds.

Design and Use of the Full System

Figure 5-7 shows a block diagram of the hardware test and how we set it up. As explained earlier, the blinds were mounted to a plywood board for testing purposes. The motor was mounted above the blinds with a pulley and fishing line to control the blinds. The motor was then connected to the motor driver on the proto-board. The other wire coming from the blinds leads to the outdoor light sensor, not pictured because it sits behind the blinds. This sensor is connected directly to the Arduino. Next, the motor driver and indoor light sensor are wired from the proto-board to the Arduino. On the proto-board, the red box represents the motor driver, the blue box represents the indoor light sensor, and the black dots represent buttons, used for manual control of the blinds, if a change in light intensity is desired by the user. Lastly, to power the Arduino, it is connected to a DC-DC converter to provide 5V to the Arduino from a 48V power supply.

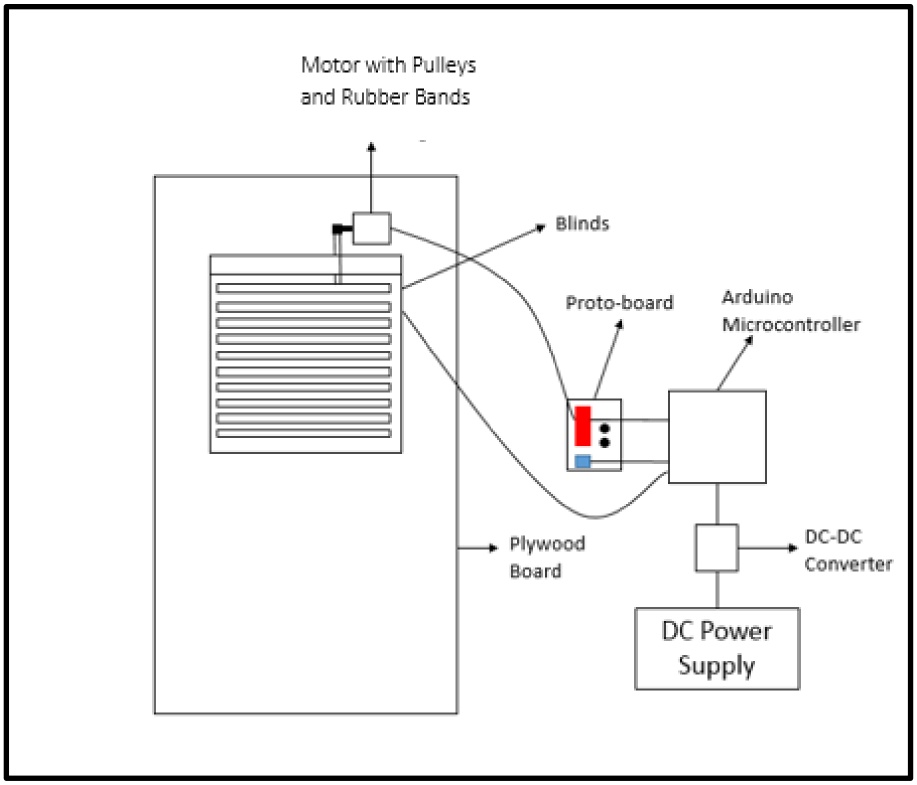

Figure 5-7. Initial Hardware Test Block Diagram

Figure 5-8 shows the full system as it was setup to test. From left to right on top of the blinds are the motor, the pulley/rubber band system, the Arduino, a battery taped down, the protoboard, then the long wires leading to the second light sensor. To operate the full system, there are two different options are far as powering up the system. First, you can attach a 9V battery and plug the leads into the Vin and GND terminals of the Arduino to power the entire system. Second, you can plug an USB-Printer Cable cord into the printer cable port of the Arduino. This would allow the user to operate the system from any USB port, for example, any computer could be used to run the system, without the need for a battery.

Figure 5-8. Image of the Full System Test Setup

The next step in operating the system is to adjust the light level to the level the user desires. This is done by pressing the two buttons on the protoboard, one of which opens and one of which closes the blinds. The idea is the user will set the desired light level, and as the day gets lighter or darker, the blinds will automatically open or close to maintain the same light level inside the room compared to outside the room. If the system is to be installed on an actual window, make sure the protoboard with the indoor light sensor is mounted facing into the room, while the second light sensor is mounted to face outdoors. For testing purposes, the user can show the system operation simply by adjusting the light levels on the two sensors. For example, increase light on the outdoor sensor and decrease light on the indoor sensor, and the blinds will open.

Chapter 6. Conclusion

To begin this report, the abstract stated the overall goals for the project. This was to design a smart blinds system that will have the ability to run on its own, thus saving the user energy by taking advantage of outdoor lighting when it is sufficient and available to light the room. This goal was achieved using a blinds system that incorporated an Arduino, two light sensors, a motor and motor driver, and pulley system to open and close the blinds. This project proves that this is a viable option for homeowners looking to cut down on their energy bill. Throughout the project, slight issues were found and addressed, the biggest of which was gaining enough traction on the pulleys to pull the blinds with enough strength. Once this problem was addressed and all of the components were successfully tested, it was a matter of mounting the full system and testing it. Fortunately, these tests went very well, and the blinds operated as intended.

Now that this project has been completed, there is plenty of future work that can be added onto it. First of all, to save even more energy, this system could be integrated with a light dimmer system, giving it control of both indoor light levels and outdoor light levels using a blinds and a dimmer switch system. Currently, there is one operational blind, so other work could be to install this system on every window within a home or building, and network these windows together to make the most efficient use of indoor and outdoor lighting. Lastly, once these future projects are completed, the ultimate goal is to have the system installed within Professor Taufik's DC Smart House.

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Appendix A - Senior Project Analysis

Project Title: Light Sensing Smart Blinds
Students: Andrew Hodges, Ryan Flick
Advisor: Taufik

1. Summary of Functional Requirements
    a. This project will be able to sense the amount of light outside the window and in the room, and then adjust the angle of the blinds. This way, the light source will not be running at maximum power output while there is excess light coming through the window. It will be controlled using a microcontroller, which will read the data from the photodiodes and the to calculate at what angle the blinds should be at.
2. Primary Constraints
    a. There are a couple of constraints that will be tough as we assemble this project. The first is to make sure the servo motors can generate enough torque to move all the blinds smoothly without getting jammed. The next constraint is to figure out a cheap, but acceptable microcontroller that will have the processing power needed for our design. Trying to minimize the cost will be very vital as we market the product. Finally, a big constraint is being able to effectively measure the ambient light inside and outside the room. The project relies on the photodiodes accurately reading the light levels to decide when there is enough light outside, that the light source does not need to emit any light.
3. Economic
    a. What will impact the result?
        i. Human Capital: The development of this device creates jobs in engineering, manufacturing, sales, and marketing.
        ii. Financial Capital: This device will sell and create profit for investors and will create a new niche within the automated blinds market.
        iii. Natural Capital: The project will use both mechanical and electronic components, using a microcontroller, photodiodes, light source, servo motors, and physical blinds. These parts are difficult to dispose of because of the different materials required to make them.
        iv. Costs: The commercial sale price is subject to change, as the projected component prices may vary after further research is conducted. An estimated production cost of $125 for a small array of blinds, leading to retail price of $150-$200.
        v.

Table 6: Cost Evaluation

Purchase	**Cost**	**Explanation**
System Cost	$126.44	Total for Component Parts According to Appendix C
Website	$1,000-$2,500	Estimated Cost of Hiring a designer, maintenance, and buying a domain name

Testing	$1,000	Professional testing of product
Labor	500 Hrs ($10/Hr)	Optimistic Labor Cost
Total	$7,071-$8,762	

These estimations make up the entire cost of developing our product and launching it, including having it tested. At just the senior project level, our cost will not exceed $200.

Using the equation from Ford and Coulson Chapter 10, the optimal cost would be (cost1) = 450hrs x $10 = $4,500. The least optimal cost would be (cost2) = 550hrs x $14 = $7,700. The most likely cost would be (cost3) = 500hrs x $12 = $6,000. The result labor estimation is:

$$Cost = \frac{cost1 + 4cost3 + cost2}{6} = \$6{,}033$$

4. If manufactured on a commercial basis:
    a. Estimated number of devices sold per year: ~1000 units
    b. Estimated manufacturing cost for each device: $69 (See above)
    c. Estimated purchase price for each unit: $125
    d. Estimated profit per year: $31,000
    e. Estimated Cost for User to operate device: $0.01/Hr (Electricity Cost)
5. Environmental
    a. The environmental impacts occur due to the fabrication of all the parts used for this project, especially the microcontroller, servo motors and photodiodes. Correct recycling of these parts is necessary, or else harmful chemicals may harm the environment affecting people and animals that live near it.
6. Manufacturability
    a. Manufacturing of this project will be very complex due to the number of components required to construct this system. With motors, microcontrollers, and a physical blinds system, manufacturing will be very tough.
7. Sustainability
    a. Describe any issues or challenges associated with maintaining the completed device.
        i. One issue with maintaining the device, is ensuring that the components are well protected and will not be damaged easily, specifically the photodiodes. Another challenge is to ensure that the blinds will not become jammed, which might cause the motors to break.
    b. Describe how the product impacts the sustainable use of resources.
        i. When manufacturing this product, the recycling of parts must be monitored to ensure the product does not have a huge environmental footprint.
    c. Describe any upgrades that would improve the design of the project.
        i. An improvement of the mechanical system of the blinds would greatly benefit this project. Ensuring that the blinds do not jam and that the rest of the parts are well protected are very important for this project, to make sure the product lasts a long time.

d. Describe any issues or challenges associated with upgrading the design.
    i. To upgrade the design, a new blinds mechanical design would be helpful without having to physical "hack" or change a new set of miniblinds. This would require a person with knowledge of materials, pulleys, and machine working to construct a new design that is sturdy, cheap, and efficient.

8. Ethical
    a. One ethical implication of this product is the benefit of reducing energy consumption by utilizing light through windows. A negative implication is that due to the amount of parts being used, manufacturing this system will not be very environmentally friendly, unless all parts are recycled correctly.
9. Health and Safety
    a. One safety concern with this project is that a few of the components will be exposed and could be protruding enough to poke somebody if they walk too close to the system. Along these lines, if something is wrong with the motors, there is no way to manually adjust the blinds because this is a purely automated system. Children getting caught in the blinds could be a concern because of this.
10. Social and Political
    a. Social issues with this design include that some customers will benefit more than others for this project. In places with little sunlight, the system will not be used to its full potential, and will instead just use the light source inside. Political issues include that correct advertising must be present, or legal issues will occur as well as bad ethics reflected on our company.
    b. This project affects the whole automated blinds industry, including companies like Chicology and Draper. They will lose more market share, and may try to create a competitive system like this one. Advertising using platforms like Amazon, social media, and Google searches will also be affected since we must add that into our cost.
11. Development
    a. Some new tools utilized are Arduino libraries for the TSL2561 light sensors, in order to setup the sensor and read the light sensing data in lux. Arduino is all open source, so the library is very easy to find online.

Appendix B: Timeline of Tasks of Milestones

Winter Quarter Timeline

	Week #										
	1	2	3	4	5	6	7	8	9	10	11
Determining the type of blinds/curtain	■	■	■	■							
Review and redo block diagram			■	■	■						
Component sizing and selections					■	■	■				
All required components acquired						■	■	■	■	■	■
Bill of Materials										■	■

Spring Quarter Timeline

	Week #										
	1	2	3	4	5	6	7	8	9	10	11
System design and (if any) simulation	■	■	■	■							
Chapter 4 Draft to taufik@calpoly.edu					■						
Hardware construction and testing					■	■	■	■			
Chapter 5 Draft to taufik@calpoly.edu									■		
Chapter 6 Draft to taufik@calpoly.edu										■	
Senior Project Demo to Taufik										■	

Appendix C: Bill of Materials

Count	Description	Part Number	Manufacturer	Per Unit Cost $
1	STEPPER DRIVER 0.75A 30V LOAD	ROB-12779	SparkFun Electronics	14.95
1	STEPPER MOTOR HYBRID BIPOLAR 24V	316020003	Seeed Technology Co., Ltd	14.79
1	PC BOARD 2-SIDE PPH 2.0X3.0	8029	Vector Electronics	6.72
1	ARDUINO UNO BOARD REV3	A000066	Arduino	23.38
1	9V BATTERY	43946	Rite Aid	5.92
1	SMAKN DC-DC CONVERTER BUCK	RC8-60S0505	SMAKN	15.79
2	CORNER BRACE	30699150694	Home Depot	2.98
2	SWITCH TACT 6mm MOM 150 GF	B3F-1022	Omron Electronics Inc	0.36
1	MINIBLIND	4719867344788	Home Depot	3.98
2	ADAFRUIT LIGHT SENSORS	TSL2561	Adafruit	5.95
1	STEPPER MOTOR BRACKET	A00611A01	LANMU	7.99
4	50mm M3 SCREWS	a15070200ux0102	UXCell	0.67
2	5mm BORE PULLEYS	O3D037	Orish	10.99
			Total:	126.44