Modular Light Matching Network

ECE 445 Design Document Check

Joshua Magid, Richard Yan, Elizabeth McKenna
Group 62
TA: Ali Kourani

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1. Introduction

We will be building a light system for work-from-home employees who want to emulate natural lighting and conserve energy during a normal work day. Our customers have the issues of eye strain and unhealthy sleep schedules due to their harsh and monotone room light. A survey done by AJMC shows that 67% of people believed their sleep schedules were healthier before Covid19 [1]. The average electricity bill has also gone up by an average of $127 based on a PRNewswire analysis [2]. Our product will be able to mitigate both these factors by color and intensity matching natural light streaming through your window and turning off lights as you enter or leave a room.

2. High-level Requirements

a) Matches intensity of outdoor lighting within ±10% in lux (unit of brightness). Matches color of outdoor lighting enough to be indistinguishable to the naked eye, within approximately ±10% in °K (color temperature).
b) A yellow light will turn on when the outdoor light intensity falls below 450 lux (average lux necessary for reading).
c) The light system will turn on and off when a person enters or leaves the room through an average door frame of 36 inches wide. Will be able to count the number of people in a room and only turns off when nobody is in the room.

3. Block Diagram

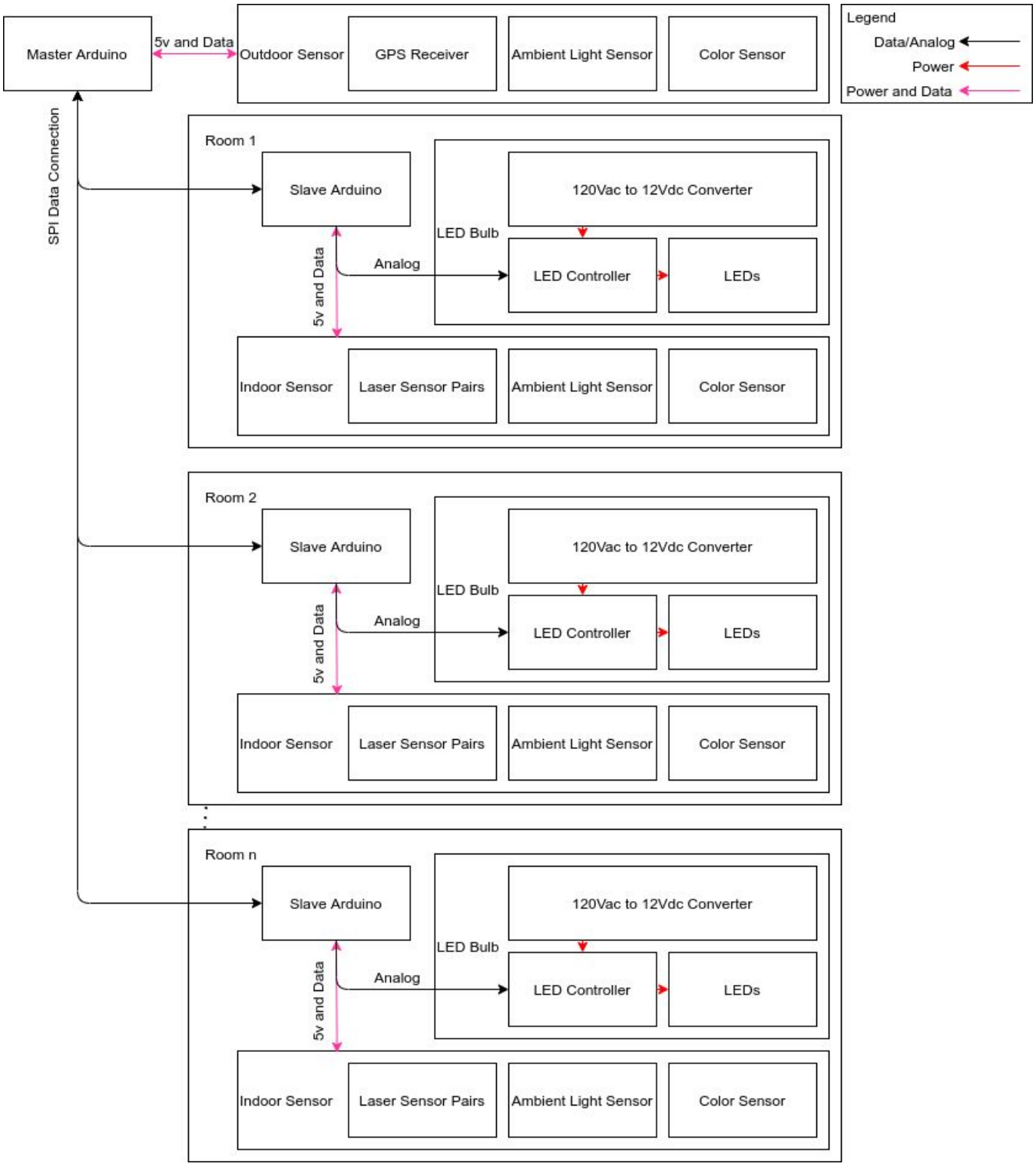
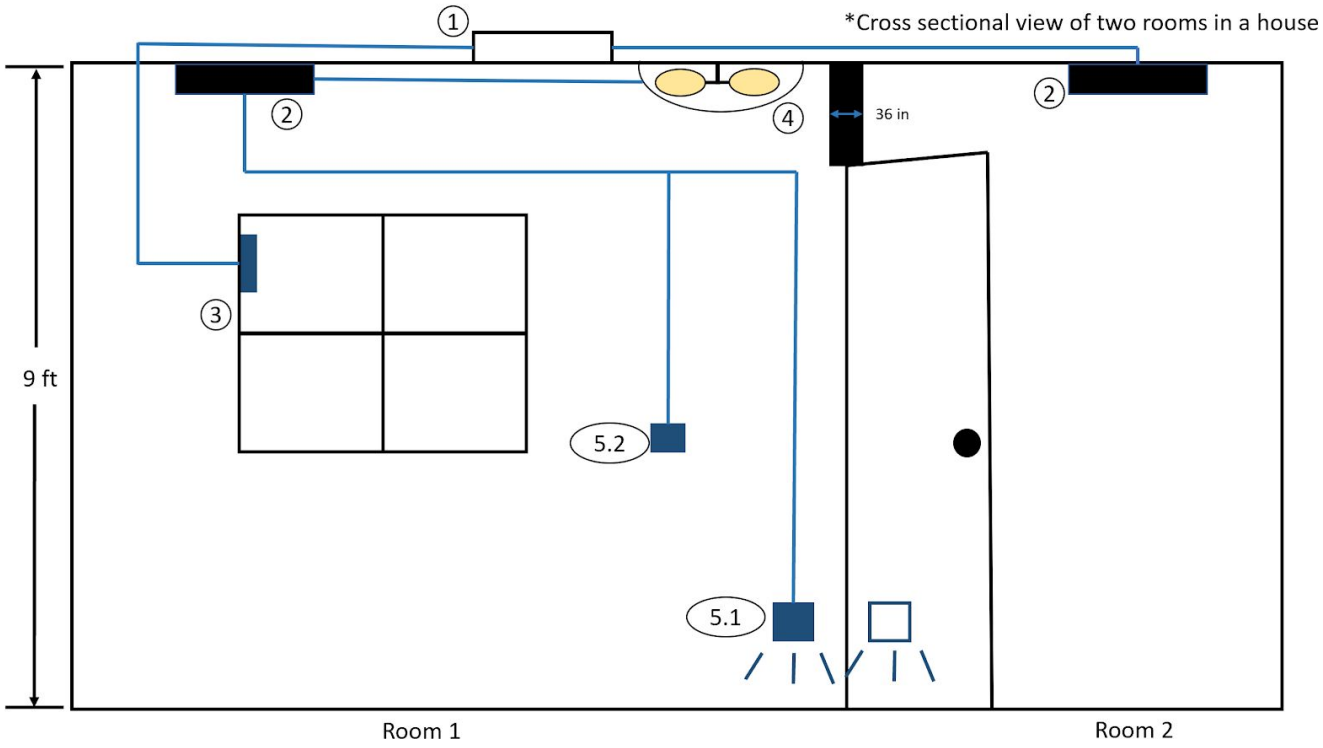


Fig. 1 Block Diagram

4. Physical Design



1. Master Arduino
2. Slave Arduino
3. Outdoor Sensor including GPS Receiver, Photoresistor, and Color Sensor
4. LED Bank including LED Controller and PSU, and LEDs
5. Indoor Sensor
   5.1: Laser Sensor Pairs
   5.2: Photoresistor and Color Sensor

Figure 2 : Physical Design

The physical design shows the lighting system including one and a half rooms. Each room has its own slave arduino which is contained inside a box and mounted to either the wall or ceiling. The slave arduino communicates with the LED bank and indoor sensors. Each slave arduino is also connected to the master arduino which is connected to a power supply through the house and gathers information from the outdoors sensors including the GPS receiver, light sensor, and color sensor. This information is then communicated to each of the slave arduinos which turn on the correct lighting if necessary.

5. R&V

Light sensor network:

Requirements	Verification
1. Operate the light sensor within the linear regime of its resistance vs. lux curve. 2. Be under 2000 lux indoors. 3. Maintain temperatures below 75°C.	1. Place the sensor in an area that senses ambient lighting of varying brightnesses. Note various lux values measured and the maximum and minimum values. 2. Find the optimal position where it is not subjected to direct sunlight ~100,000 lux. 3. Scale down maximum brightness of outdoors to a maximum of 2000 lux for indoors. 4. Use a temperature gun to ensure LDR does not exceed operating temperature of 75°C. Cover with translucent film if necessary to prevent overheating.

LED Bank:

Requirements	Verification
1. Light intensity output must be within ±10% lux to the given input. 2. Light color output must be within ±10% °K to the given input.	1. Utilize an LDR to measure intensity of the indoor light. 2. Use a multimeter to ensure illuminance readings between indoor and outdoor light levels are within ±10% lux. 3. Utilize an indoor color sensor to ensure indoor and outdoor color temperatures are within ±10% °K.

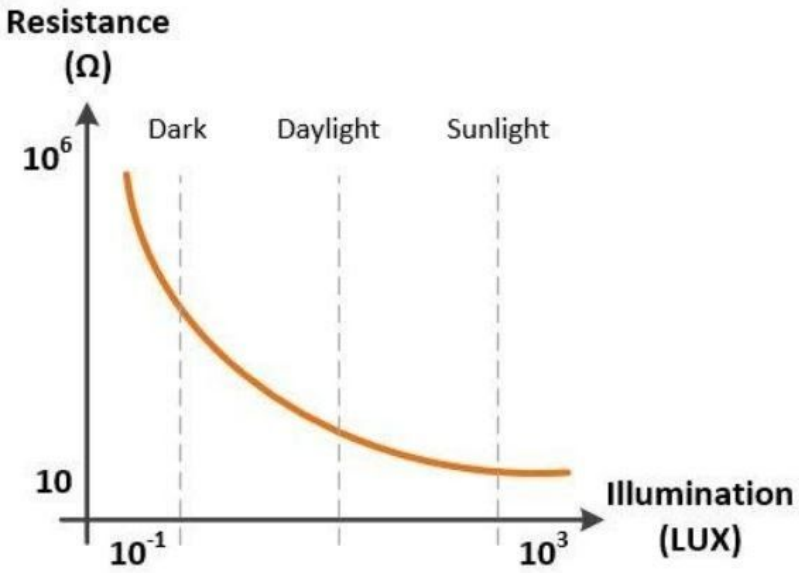
Power supply:

Requirements	Verification
1. Voltage output is limited to 12 ± 1 V. 2. Voltage input properly rectified and stepped down from 120 ±10 V AC to the 12 V DC.	1. Use a 120 V AC to 12 V DC converter to step down voltage. 2. Use a 12 V linear regulator to ensure ± 1 V. 3. Test and verify through the use of an oscilloscope that the system stays within 10% of its intended values

Dimmer circuit:

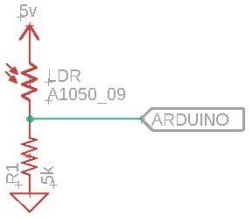
Requirements	Verification
Dim 12 V LEDs with flickering below human eye perception.	1. Use an oscilloscope to measure the duty cycle and frequency of the timer chip and note frequencies that are uncomfortable to look at. 2. Raise frequency to above 200 Hz (ideally 1000 Hz) and change duty cycle to get full range of dimming.

5. Plots



A resistance vs. lux curve is not entirely linear, as it becomes more logarithmic at the extremes. We will limit this by placing the LDR circuit inside a translucent layer, which will help shave off extremal regions.

6. Circuit Schematics



Ambient light sensor

7. Tolerance Analysis

In order for this system to function properly the main design element that must be completed correctly is the LED bank. The LED bank must be able to properly output the correct light intensity to within ±10% lux and correct light color to within ±10% °K.

8. Safety & Ethics

There are a couple of safety considerations that arise with this project. A major goal of the project is to uphold the "IEEE Code of Ethics" by creating a system that benefits society while ensuring that the safety and well-being of the public is the highest priority [3]. The system will follow the "ACM Code of Ethics" by disclosing all information to the public and ensuring that the consumer is aware of all risks associated with the product [4].

One of the first major ethical issues is related to privacy concerns. The IEEE Code of Ethics is dedicated to protecting the privacy of the public [3]. This system may cause privacy concerns because of the fear an outside source may hack the lighting system. If an individual's home lighting system was compromised then the hacker would be able to turn on and off the lights at any point causing fear for the user's safety and privacy. This project goal is to ensure that situations like this will not occur and an outside source would not be able to access the entire lighting system. To protect against this issue the system will not require connection to a wifi which will decrease the risk of the system being hacked.

Another major issue is related to safety issues in the event that the LED lights burn out and start a fire. While LEDs are much safer than the older more traditional light bulbs there is always the possibility of danger. This project deals with the major fire issues that are a concern with incandescent lighting because LEDs do not get as hot or produce heat [5]. Overall, this system will deal with overheating hazards by ensuring that the light system is turned off when not in use and using a proper heatsink. Additionally, the system will only use LED bulbs that have been

rated with high safety ratings and standards. The project group has also completed the lab safety courses to ensure that all trials and tests are completed in the safest manner possible.

Mental well-being concerns is another issue that arises with this project. Poor or incorrect lighting can cause anxiety, stress, and other mental health issues [6]. There is a concern that this system would increase these issues caused by bad lighting. This project is aiming to correct an individual's everyday light exposure and, through research on the topic, the system will be able to improve the overall health of the user. Warm colored and dim lights have been proven to not only improve an individual's circadian rhythm but also increase production of both melatonin and glutamate [7]. This system will produce the necessary warm colored lights while dimming the lights at appropriate times to ensure that it creates a healthier lifestyle.

The last safety/ethical issue deals with light pollution. This is a huge environmental issue that can also affect an individual's health. The impact of individual households adds to the issue of light pollution, and there is an ethical concern by creating a system that will cause excessive light pollution. While this project does add to the issue, it reduces the amount of pollution that a typical lighting system would emit. This is because our system will sense when additional lighting is necessary and dim or shut off the lights when they are not required. The laser detection that is included in the system will ensure that the lights in a room remain off when it is not in use.

With all of the safety and ethical concerns taken into account, the system will reduce any negative effects that could arise. It will follow both "IEEE Code of Ethics" and "ACM Code of Ethics" to create a safe environment for the user at all times.

9. Citations

[1] "How Have Sleep Habits Changed Amid COVID-19?," *AJMC*. [Online]. Available: https://www.ajmc.com/view/how-have-sleep-habits-changed-amid-covid-19. [Accessed: 15-Feb-2021].

[2] Sense, *Sense Data Shows Americans Paid Higher Electricity Bills in 2020, Impacted by Covid-19 Restrictions, Wildfires and Heat Waves*, 19-Jan-2021. [Online]. Available: https://www.prnewswire.com/news-releases/sense-data-shows-americans-paid-higher-electricity-bills-in-2020-impacted-by-covid-19-restrictions-wildfires-and-heat-waves-301210985.html. [Accessed: 28-Feb-2021].

[3] "IEEE Code of Ethics," *IEEE*. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 15-Feb-2021].

[4] “The Code affirms an obligation of computing professionals to use their skills for the benefit of society.,” *Code of Ethics*. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 15-Feb-2021].

[5] Eugen, Nicholas, B. T, and L. Lang, “Can LED Lights Be Left on 24/7 and Why You Shouldn't Do It! - LED & Lighting Info,” *LED & Lighting Info - Useful Tips To Improve Design*, 23-Dec-2020. [Online]. Available: https://ledlightinginfo.com/can-led-lights-be-left-on-24-7#:~:text=Overheated%20bulbs%20are%20dangerous%20as,a%20lower%20watt%20light%20fixture. [Accessed: 16-Feb-2021].

[6] “Find the Right Light: How Lighting Can Affect Your Mental Health,” *GROW Counseling*, 01-Mar-2019. [Online]. Available: https://growcounseling.com/find-the-right-light-how-lighting-can-affect-your-mental-health/. [Accessed: 15-Feb-2021].

[7] “Do Warm-Colored Lights Help Sleep?,” *Next Step 2 Mental Health*, 30-Jul-2020. [Online]. Available: https://www.nextstep.doctor/do-warm-colored-lights-help-sleep/. [Accessed: 01-Mar-2021].

pichttps://www.researchgate.net/publication/330116999_Automatic_AC_Controller_with_a_Real-Time_Feedback_System/figures?lo=1