Motorized Track Lighting System

Team 80
University of Illinois at Urbana-Champaign ECE 445
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Schedule:
Sat 12/16: objective, background, block diagram (and begin analysis of components), ethics and safety, 3 high level requirements
Sun 12/17: requirements and verification (tolerances?), mechanical, circuit schematics
Mon: schedule & cost
Tuesday: design check, work on all
Wednesday: meet TA, work on all

Must Include:

- Introduction/High-level Requirements
- Block Diagram
- Physical Design (if applicable)
- Requirements & Verification Tables
- Plots
- Circuit Schematics
- Calculations
- Safety & Ethics
- Citations

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1 Introduction

1.1 Objective

Current lighting solutions for home, museum, and studio use are often static systems. While they can be useful in fixed environments, if the environment they are meant for use in is rearranged regularly, manually adjusting the lighting solution is a frustrating and potentially dangerous process.

The objective of our project is to create a remotely controllable track lighting system. Our goal is to build a track-based system in which multiple lights can be moved. The degrees of freedom available to each each light cart will allow them to move left and right along a shared linear track, and to pan the bulb mount 360 degrees, and tilt the light through a range from 0 degrees (beam straight down) to 90 degrees (beam horizontal). This product should give artists, gallery owners, and homeowners the ability to change focuses of their lighting solutions on demand.

Benefits

This product will make arranging lighting in a space simpler. The user will not need to modify the lighting configurations manually, risking burns from hot bulbs, electrical shock or falls from high ladders. The user will be able to move individual light carts along the track and change the direction the light bulb is shining through a cell phone application communicating with the light system over Bluetooth.

Features

Ease of use is the most important marketable aspect of this project. Our remotely controlled system will mitigate much of the physical hassle of manually iterating on a lighting setup. In turn, this will bring dynamic lighting solutions to users who may be physically unable to balance on a ladder and reach above their heads. In addition, this lighting solution allows the user to view the changes they are making to the lighting in a space from the vantage point that viewers, customers, or themselves as artists will have of the illuminated subject.

1.2 Background

1.3 High-Level Requirements

(Bullet points, what the design should accomplish)

- On a 6 foot track, two light carts should be able to be configure their lateral positional and rotational position independently solely through bluetooth communication
- DD
-
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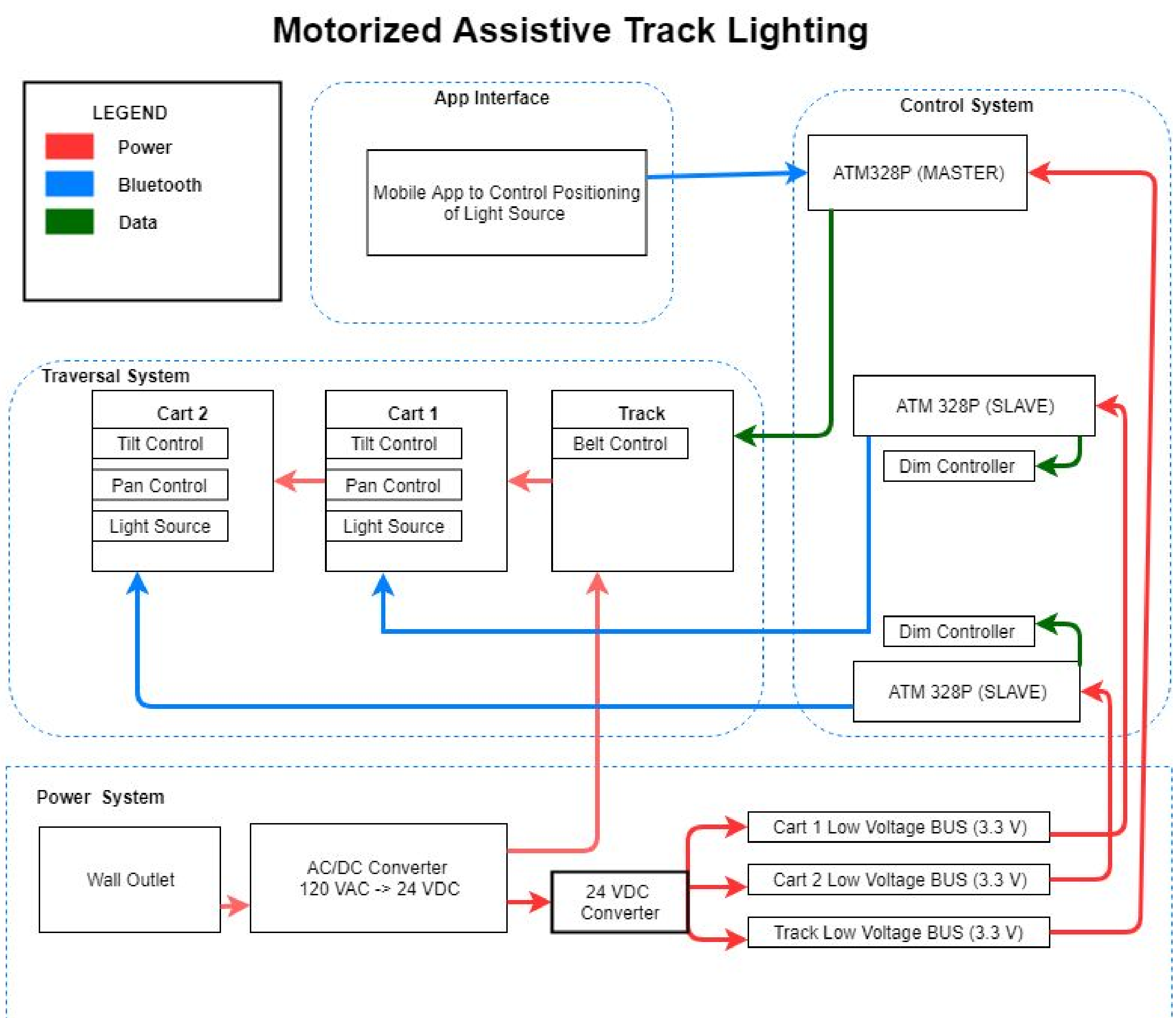
The better high level requirements

- The light carts must move along the track at a speed of 3 inches per second in a continuous motion.
- The light bulb source must be able to pan around its axis the full 360 degrees.
- The control module must be able to turn on and off individual light bulbs when there are multiple carts on a track.

(Updated Block Diagram)
Figure 1. Block Diagram



(Physical Design Sketch)
*We should add multiple sketches

Figure 2. Physical Design Sketch

2.1 App Interface

The application interface portion of the block diagram in figure X is the high level interface between the motorized track system and the user. Through a bluetooth connection, the user will be able to communicate to the Master ATM328p processor in the control module to reference the appropriate light cart. The application interface will be an Iphone app that will be comprised of a simple UI layout with buttons to designate the different lateral directions. An example can be seen in figure X

2.1.1

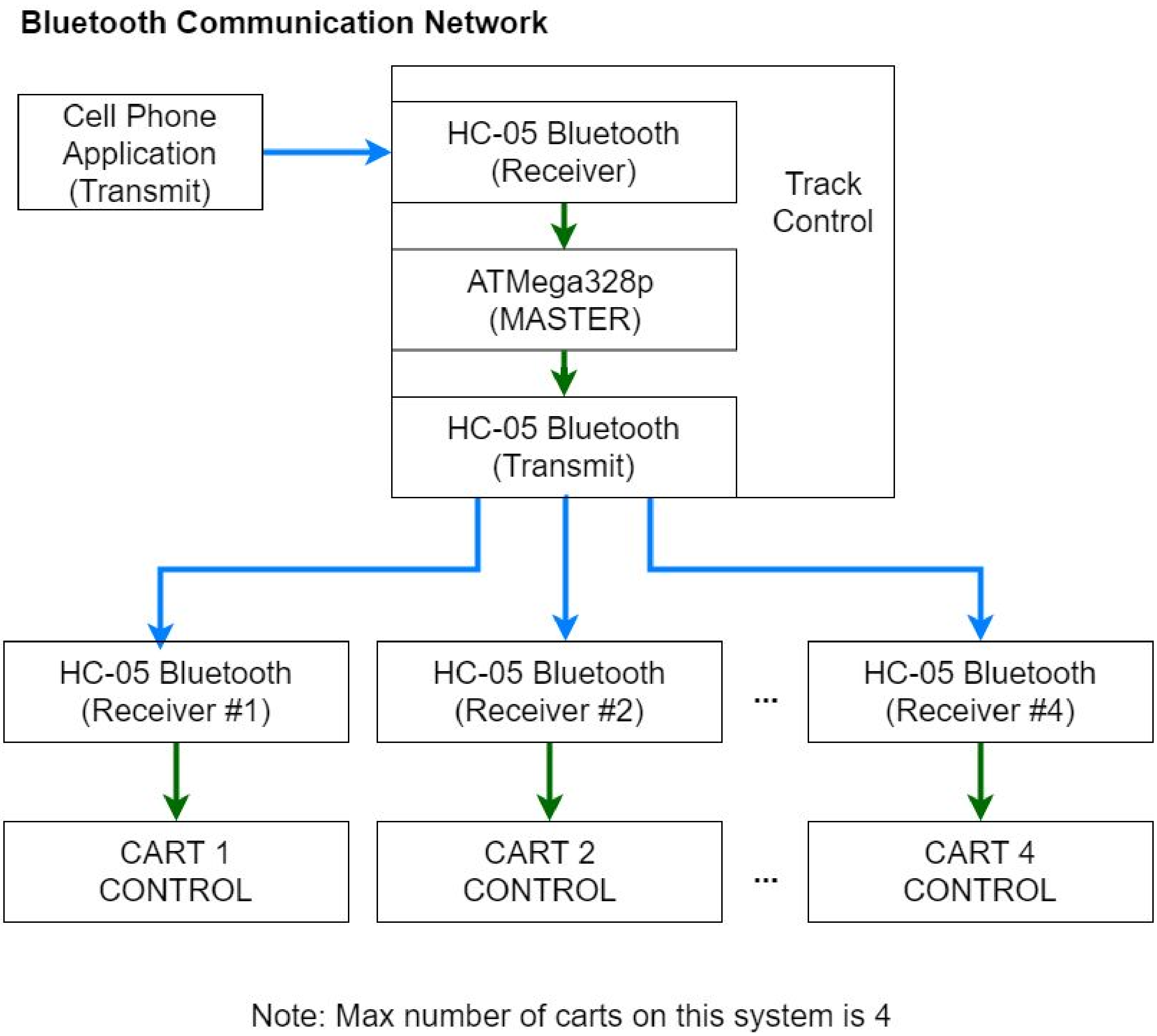
Requirement	Verification
1. Control each light cart to traverse the full length of available track to within 4±2 inches of the next cart or the end of the track as determined by limit switches	1. a. Start with the cart in an arbitrary position on the track b. Drive the cart away from the driven end of the belt until it reaches a limit switch (end of track or another cart) c. Drive the cart towards the driven end of the belt until it reaches a limit switch
2. Select which light cart on the track to send instructions to	2. a. Connect to the track b. Select an arbitrary cart c. Send an arbitrary instruction (or sequence thereof) d. Observe that the instruction is carried out by the selected cart
3. An instruction should be carried out on the selected cart within 1.5 seconds of being sent from the app	3. a. Use a stopwatch to time the delay between sending an arbitrary instruction from the app and the action being carried out
4. Move the specified cart forwards and backwards along the track	4. a. Send the move cart forward instruction and observe actuation b. Send the move cart backward instruction and observe

5. Turn the selected cart’s light source on and off 6. Pan the selected cart’s light source 7. Tilt the selected cart’s light source 8. Connect to the master ATM328 Processor within 10(±2) seconds	actuation 5. a. Using the on and off instructions from the app, cycle power to the light source b. Observe that the selected cart’s light source turns on and off 6. a. Send the pan clockwise instruction and observe CW actuation b. Send the pan counterclockwise instruction and observe CCW actuation 7. a. Send the tilt up instruction and observe that the tilt kit actuates tilting up until a maximum of 90 degrees (or to a limit imposed by the physical dimensions of the light source) b. Send the tilt down instruction and observe that the tilt kit actuates tilting down until a to (or to a limit imposed by the physical dimensions of the light source) 8. a. Check that the app is not connected to the master ATM328 Processor b. Initiate connection sequence from the app c. Keep track of time until connection confirmation on the app and make sure it takes the appropriate amount of time

2.2 Control System

The control system is made up of 3 ATM328 Processors: 1 master and 2 slaves. The app will only interface with the master processor, which will then relay the communication to the 2 slaves. The user would send commands such as move a specific cart back and forth, or tilt a specific light through the app, and then the master processor would relay those commands to the respective slave processor.

In this diagram, we have only included descriptions for 2 light carts, but the design is expandable to account for more carts, as allowed by the length of the track. The design would require as many slave processors as there were light carts.



2.2.1 ATM328 Processor (Master)

Master processor will be able to receive these instructions from the app and then relay them to the specified slave processor:

- Turn on/off the light source
- Dim the light source
- Pan the light source
- Tilt the light source

- Latch on to the traversal belt

In addition, the master processor will be responsible for the belt drive motor control circuit.

Requirement	Verification
1. Send signals to both of the slave processors simultaneously	1. a. Select an arbitrary slave b. Relay an arbitrary instruction c. Observe the instruction being carried out

2.2.2 ATMP328 Processor (SLAVE 1)

The slave processor will be able to receive these instructions from the master processor and then relay them to the appropriate mechanical or electrical subsystem on its cart:

- Turn on/off the light source
- Dim the light source
- Pan the light source
- Tilt the light source
- Latch on to the traversal belt

Requirement	Verification
1. Slave processor must be able to send instructions to its subsystems on the cart to turn the light on/off, dim the light, latch, pan and tilt	1. a. Ensure the light on/off instruction toggles power to the light source b. Ensure the latch instruction engages the latches to catch the timing belt so the cart can be moved c. Ensure the pan clockwise/counterclockwise instructions can rotate the pan kit [-180..180] or full 360 degrees d. Ensure the tilt up/down instructions can adjust the angle of the tilt kit between [180..90] degrees from +z axis

**do we need to list out all the individual requirements? We could possibly just refer back to all the instructions that the app has to be able to send.

2.2.3 ATMP328 Processor(SLAVE 2)
(same capabilities as slave 1)
(Do we need to copy paste?)

2.3 Traversal System

2.3.1 Motorized Track

The motorized track will operate by running a vertically mounted stepper motor to drive a timing belt going from the stepper motor to a fixed toothed pulley mounted on the other end of the track. The motor must be driven both forwards and backwards upon receiving instructions from the master processor. When a drive instruction is received by the master bluetooth node, it must relay a latch instruction to the light cart currently selected by the user. The cart will latch to the belt within the next 1.5 seconds. After some small delay slightly longer than the time it takes the cart to latch via servo (a time will need to get an average measurement of–ideally we will operate with as short of a delay as possible), the stepper motor will begin driving the belt in the direction that will actuate the user's desired instruction (depends on which side we determine it's easiest to latch to the belt from, we tacit here that by symmetry it won't matter).

Requirement	Verification
1. The track stepper motor driver must be able to receive forwards and reverse signals from the Master ATM328 Processor 2. The track motor must be able to move forwards and backwards on command from signals sent from the Master ATM328 Processor	1. With an oscilloscope: a. Validate the signal produced by the ATM328P being sent to the motor drivers against datasheet requirements **(need to look into specific parts)** b. Validate the signals produced by the motor drivers before attaching them to the motor by comparison with the motor driver datasheet 2. a. The torque must overcome the coefficient of friction of UHMW against aluminum **(find this!)** times the weight of the light cart b. The forward drive signal must make the motor rotate the correct direction (without loss

	of generality) to move a latched cart away from the motorized end c. The reverse drive signal must make the motor rotate the opposite direction as the forward drive signal to move a latched cart towards the motorized end

2.3.2 Cart 1

Each cart will house a light source and
Motors on this cart should be able to do these things on command from its slave processor

- Turn the light source on and off
- Pan the light source
- Tilt the light source
- Latch on to the timing belt

Requirement	Verification
1. The latching servo motor(s) must be able to latch on command from its respective slave ATM328 processor 2. The pan servo must be able to pan on command from its respective ATM328 processor 3. The tilt servo must be able to tilt on command from its respective slave ATM 328 processor	1. a. Servos should actuate arms to pinch the belt within 1.5 seconds to maintain the responsiveness of the system b. Effective latching means the pinching force overcomes the force required to overcome the static coefficient of friction of the linear bearing on the track 2. a. Full 360 degrees or +/-180 3. a. Tilt +/-90 or tilt 90 to 180 from +z

2.3.3 Cart 2
(same capability as cart 1)

**The requirements and verification procedures will be identical for each light cart on the motorized track

2.4 Power System

2.4.1 Wall Outlet

The system as a whole will be able to be plugged into the wall outlet and run on 120VAC. This power will then need to be converted to DC voltage in order to power all the internal components.

Requirement	Verification
1. Supply uninterrupted power to the motorized track system	1. a. Using an oscilloscope, observe that the voltage from the wall is 120VAC with a frequency of 60 Hz

2.4.2 AC/DC Converter

Requirement	Verification
1. Successfully convert the 120VAC power from the wall outlet to 24 VDC (±5%) needed to power the motorized track system	1. a. Using an oscilloscope, observe that the voltage after being converted is 40 VDC

2.4.3 Cart 1 low voltage bus

This bus is in charge of powering the slave 1 ATM328 processor

Requirement	Verification
1. Provide uninterrupted power of 24 VDC (±5%) to the carts respective slave ATM328 Processor	1. a. Using a voltmeter, verify that the bus is supplying a steady voltage within the specified range outlined in the

	requirement

2.4.4 Cart 2 low voltage bus

(Will contain identical requirements and verification as the Cart 1 low voltage bus)

2.4.5 Track low voltage Bus

This bus is responsible for powering the master ATM 328 processor

Requirement	Verification
1. Provide uninterrupted power of 24 VDC (±5%) to the master ATM328 Processor	1. a. Using a voltmeter, verify that the bus is supplying a steady voltage within the specified range outlined in the requirement

Points breakdown:
10 for power
10 for app+bluetooth
10 for track operation
20 for cart operations

(Some Testing
Results)
(Bluetooth Communication Diagram. Identify receivers and transmitters and which are talking to each other)
(Power Distribution Analysis)

4. Schedule

Week	**Adithya**	**Ethan**	**Pratik**
2/17- 2/23/2019		Discuss Track design options with the ECE metal shop	Purchase test components for cart bluetooth configuration
2/24 - 3/02/2019			Begin developing PCB version 1
3/03 - 3/09/2019			Revise circuit designs

			and begin version 2 pcb design
3/10 - 3/16/2019			Complete Final PCB design and submit order
3/17 - 3/23/2019			
3/24 - 3/30/2019			
3/31 - 4/06/2019			
4/07 - 4/13/2019			
4/14 - 4/20/2019			
4/21 - 4/27/2019			
4/28 - 5/02/2019	Prepare Final Presentation and Complete Final Report		

Ethics

(Cite sources)

Throughout the development of this product design, we will regularly consult the IEEE Code of Ethics [1] to ensure that the final product that we create aligns with this Code established by IEEE. We understand that there are safety hazards regarding this product and therefore will abide by the statement #1 “hold paramount the safety...of the public”. Appropriate safety circuitry and mounting practices will be implemented. These steps will be outlined in the following section. We will also be very explicit in the description of this product, according to #3 of the IEEE code of ethics. The accompanying manual will be clear in terms of the capabilities of this motorized track lighting system. For example, the user will know the maximum number of light carts that the track can hold, as well as features of the light carts such as the brightness of the light as well as the range of motion of the light receptacle.

We will also “reject bribery in all its forms”. A portion of this product is made up of parts manufactured by third parties. We will not accept monetary compensation in exchange for the usage of any different third party parts. It will also be a matter of public knowledge exactly which components and part numbers are used in the assembling of this product.

Included in the operational manual will also be a guide on how to control this motorized track system in order to comply with #6 of the IEEE Code of Ethics. There will be images and step-by-step instructions on how to connect to the system using Bluetooth, move individual carts back and forth, turn on and off individual light bulbs, and other necessary actions the user would need to do. Guidelines regarding maintenance and upkeep will also be present. We will include how to check that the connection to the track is live as well as basic troubleshooting suggestions should any issues arise.

Safety

(Cite Sources)

There are some safety issues regarding this product. One potential hazard would be the manner in which we are powering the system as whole. We are designing the product to draw power from a standard wall outlet, which is 120VAC. The individual components on our track take in DC voltage, so we will need to use a AC-DC transformer. This could be potentially dangerous, so appropriate safety circuits will be put in place. Light bulbs could also pose a fire hazard in the case that they overheat. The light bulbs we use will not be allowed to be powered above their rating in order to keep them from burning out.

The track system will be mounted to the ceiling. To prevent it from falling and potentially injuring anyone below it, it will be mounted securely using nuts and bolts rated for a higher weight than the anticipated track system as a whole. The user has the ability to add additional carts to the track, so this must be taken into account when calculating how we plan on mounting it. The material strength and weight capabilities of each part will be closely inspected before being incorporated into our design.

This track system will be mounted from the ceiling and therefore could possibly come in contact with water from a ceiling sprinkler or any residual moisture, so the casing that will contain the power and control modules will need to adhere to IP65 guidelines [2].

During the prototyping and testing phases of the development of this product, we will need to work in an electrical lab. We will need to power our components from the wall outlet as well as solder parts. In order to ensure our safety during this process, we have all completed the ECE 445 lab safety course. During the course of the lifetime of this product, the user or a member of the maintenance staff will need to perform occasional checks on this system. The user might also be interested in adding additional light carts to the track. As this is an expandable system, we will make this possible. In order to prevent any risk of injury to the individual in the form of burns or electrical shocks which will damage the product, an electrical safety guideline will be included in the operational manual that comes with this product. As stated before, the safety of everyone involved with this product is of the highest importance, so we will take all steps necessary to prevent any injury, Since the user connects to the track system through Bluetooth communication, theoretically anyone in the vicinity could connect to it. In order to prevent any unauthorized users from controlling the track system, we will be utilizing the user authentication protocol that Bluetooth offers. This will keep anyone with malicious intentions from connecting to the device and potentially misusing and/or damaging it.

References

1.https://www.ieee.org/about/corporate/governance/p7-8.html

2. http://www.budind.com/blog/2014/02/the-mysteries-of-ip-rated-enclosures-explained/