# Bicycle Lighting System

**Sloan Abrams, sloanaa2**
**Quentin Mooney, qmooney2**
**Jack Nelson, jnels9**

# Introduction

## Problem

The problem we are looking to solve is that cycling in the dark (be it early morning or night) can be extremely dangerous, as cyclists simply cannot be seen by other users of the road, pedestrians, other cyclists, or most importantly, motor vehicles. Even if they are visible, the cyclist's movements and intentions can still be very hard for other roadway users to discern, causing the cyclist's movements to be unpredictable, which creates danger to themselves and others. This is an enormous problem, because countless people the world over rely on bicycles for their transportation to and from work, to the grocery store, and for any travel at all. In many parts of the world, including here in Champaign, IL, for significant portions of the year this travel would all be done outside of daylight hours; both the morning commute to work and the evening commute home would require riding in the dark. Because the consequences of a collision have a very real potential to result in serious injury or death, a solution to this problem is critical.

## Solution

Our solution is to create a robust unified bicycle lighting system that allows the cyclist to be seen by other roadway users in the dark, as well as communicate their movements and intentions in the dark. We will do this by implementing a front headlight for visibility and illumination, a rear tail light for visibility, rear brake lights for communication, and turning indicators for communication. All of these lights will be under the same control system, allowing the rider to simply turn the entire system on or off as wanted with one switch. We will use sensing on the brake levers to automatically turn on the brake lights when the brakes are engaged. The lights will automatically turn off when the brakes are released. The turning indicators will be controlled by the rider via buttons on the handlebars on their respectives sides (left indicator control on left end of handlebars, right on right). The turning indicators will automatically turn off after the completion of the turn by the bike (in the same manner as a car's turn signals automatically turn off after making a turn). The implementation of these lights and indicators, all under one easily controlled user interface, will make cycling in the dark much safer for cyclists and other roadway users.
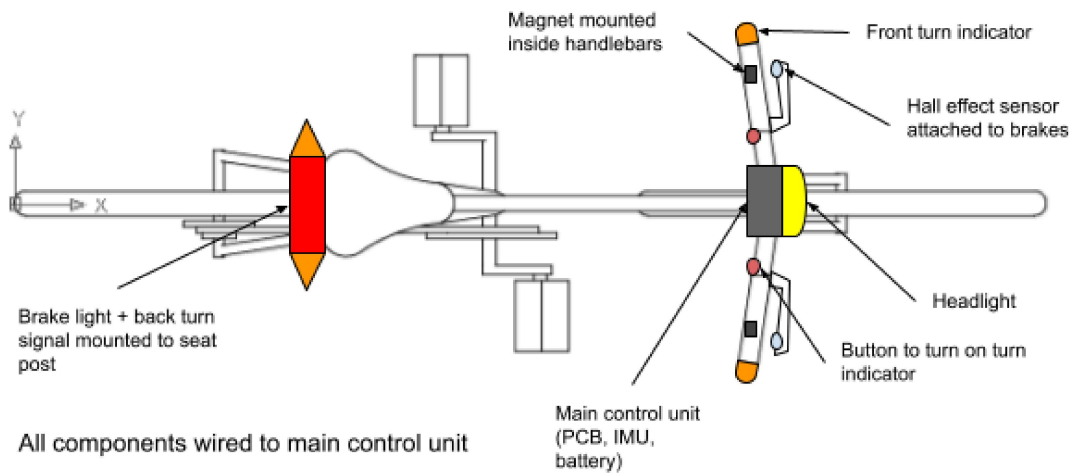
**Visual Aid**



Figure 1: Visual Aid

**High-level Requirements**

- Brake lights turn on when brakes are engaged, and turn off when the brakes are released. The brake lights are visible and distinguishable from the tail light from at least 50 feet away.
- Turning indicators are engaged in an easy and simple manner by the rider, and automatically disengage after the completion of turns of 90 degrees or sharper.
- Front light, taillight, brake light, and turn signals all function under one unified control system.
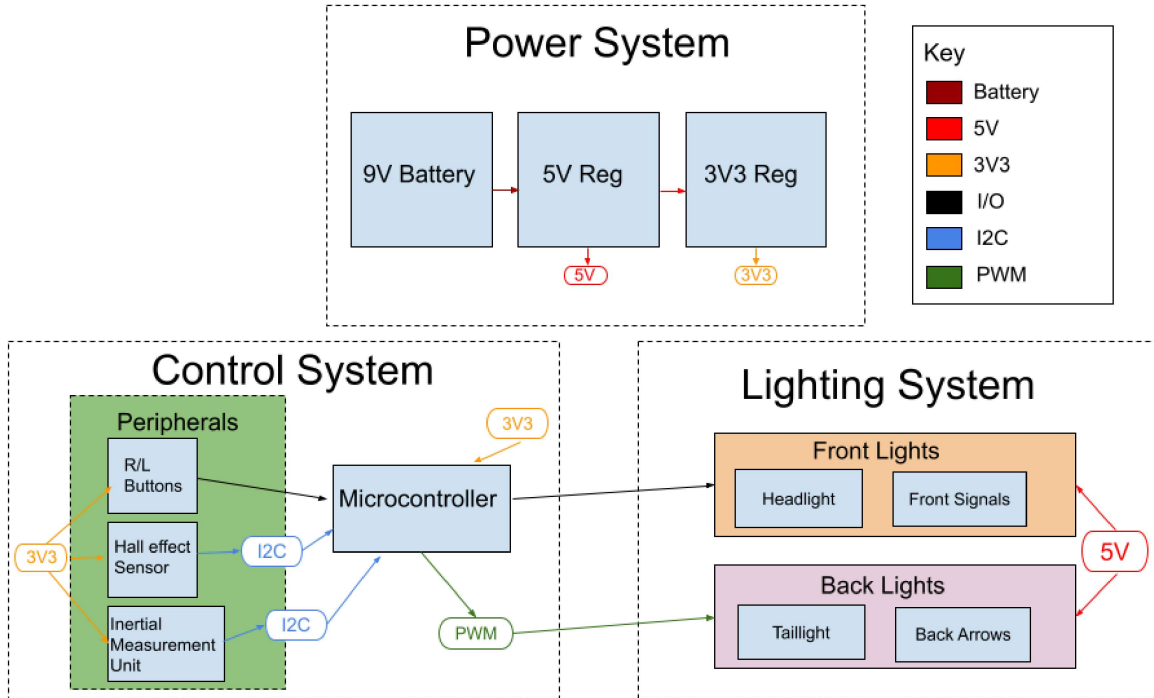
# Design

## Block Diagram



*Figure 2: Block Diagram*

## Subsystem Overview

- ### Power System

  The power system will consist of a 9V battery, a 5V voltage regulator and a 3.3V voltage regulator. The battery will feed directly into the 5V voltage regulator, which will go to both the lights as well as be fed into the 3.3V voltage regulator. The 3.3V output from that will go to the Control System components. This system overlaps with all three of the other subsystems, as they all need to be powered.

- ### Brake System

  The brake system will be composed of the brake lights, the Hall effect sensors, and the wiring connecting both of the aforementioned to our microcontroller. We will be mounting magnets inside of the handlebars, with hall effect sensors attached to the back of the brake levers. As the brake levers are depressed by the rider, the sensors will sense this, and report it to the microcontroller. The microcontroller will then turn the brake lights on. When the Hall sensors sense that the brakes have been released, the microcontroller will turn the brake lights off. The brake lights will be turned on when the left, right, or both brake levers are engaged. This will overlap with the power system and control system.

- Turn System

The turn system will be comprised of the rear turning indicators, the front turning indicators, and an IMU sensor, two user interface buttons, and all the wiring connecting these to the microcontroller. The turning indicators will be turned on by the buttons by the rider. This will turn on both the front and rear turning indicators on the respective side. The turning indicators will be automatically turned off by the microcontroller once the IMU has sensed that the turn has been completed. This will overlap with the power system and control system.

- Control System

The control system is comprised of the logic inside of the microcontroller, as well as a master switch which controls power to the entire set of lights and the microcontroller. The microcontroller logic is responsible for interfacing with the brake system and the turn system. This, the control system, will also work with the power system.

**Subsystem Requirements**

- Power System
  - The voltage rails should not have more than a 5% ripple
  - Shouldn't give off too much heat
  - Should provide enough current for our LEDs
  - Provides 5V to our lighting system, and 3.3 V to our control system.
- Brake System
  - When the brakes are pressed by the rider by more than 0.5 cm, the back taillights get brighter.
  - The taillight will return to its normal state upon release of the brakes.
  - The taillight is always on and visible from at least 50 feet away.
- Turn System
  - Turn indicators, either back or front, are visible to traffic in all directions from at least 50 feet away.
  - Turn signal turns on when the user clicks a button on the handlebars, and is disabled either when the user clicks the button again or when the user has turned 90 degrees or greater.
  - The front turn indicators should be visible to the user, to ensure the signals are not accidentally left on.
  - The buttons to turn on the turn indicators should be easily accessible and usable by the user while they are riding. They should not have to take their hands off the handlebars to access them.
- Control System
  - Centrally located, and provides communication signals to all components
  - Simple, one button on/off for the entire system
  - Should not get in the way of normal bike operation

<u>**Tolerance Analysis**</u>

We are making sure that our voltage regulators will not be giving off too much heat and break down. We are using two separate step downs, one from 9V to 5V and another from 5V to 3.3V. We are ensuring that these two step downs are feasible and better than stepping directly from 9V to 3.3V.

We do not want our regulators to exceed 50°C ambient. We got this number by finding the maximum recorded temperature in Urbana (42.7°C) [1] and knowing that the chip on the inside will be hotter than the outside temperature. This seems like a reasonable limit to set for ourselves.

The chip's maximum operating temperature is 125°C. This means that for the worst case scenario, we will have a 75°C temperature rise. According to the data sheet for the LM1117 [2] using the SOT-223 package, the junction to ambient thermal resistance is 61.6°C/W.

Using the 75°C rise in temperature we divide by the junction to ambient thermal resistance. This gets us 1.218W, which is the absolute worst case power that can draw.

Using this maximum and the equation for power, and our system if we went straight from 9V to 3.3V we would have a 5.7 volt drop, which when plugged into P=I*V gives us a maximum current draw of 213.68mA. When we compare this with our step down from 5V to 3.3V we get a voltage drop of 1.7V and a maximum current draw of 716.47mA. Our control system will be nowhere near this upper limit, so we will not need a heatsink for the heat given off by the 3.3V regulator if we have 5V as the input.

For the 9V to 5V drop, we have a voltage drop of 4V which gives us a maximum current that we can draw being 304.5mA. This means that our project will need LEDs that don't require as much current, but still is well within the range of what we'll need.

# <u>Ethics & Safety</u>

After careful review and consideration we find no ethical concerns arising from our project. There are two main relevant safety concerns. The first is that it is important for our project to work at an extremely reliable rate, as a failure in the system could lead to a user being in a potentially dangerous situation, i.e. out biking at night with no lights. We will do everything we can to ensure that our system is rigorously tested, and has backup systems for the most critical components to protect against total failure. The second safety concern is that our project is intended for outdoor, all-weather, use cases. We will ensure that water, snow, or ice won't create dangerous failures of our system.

# Works Cited

[1]     "Averages and Records for Champaign-Urbana Illinois," Illinois.edu, 2024.
https://www.isws.illinois.edu/statecli/cuweather/cu-averages.htm#:~:text=The%20record%20high%20is%20109 (accessed Sep. 18, 2024).

[2]     "LM1117 800-mA, Low-Dropout Linear Regulator." Accessed: Sep. 18, 2024. [Online].
Available:
https://www.ti.com/lit/ds/symlink/lm1117.pdf?ts=1726643965724&ref_url=https%253A%252F%252Fwww.ti.com.cn%252Fproduct%252Fcn%252FLM1117