UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Team 21: Automatic Bike Light System

Electrical And Computer Engineering

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Original Design

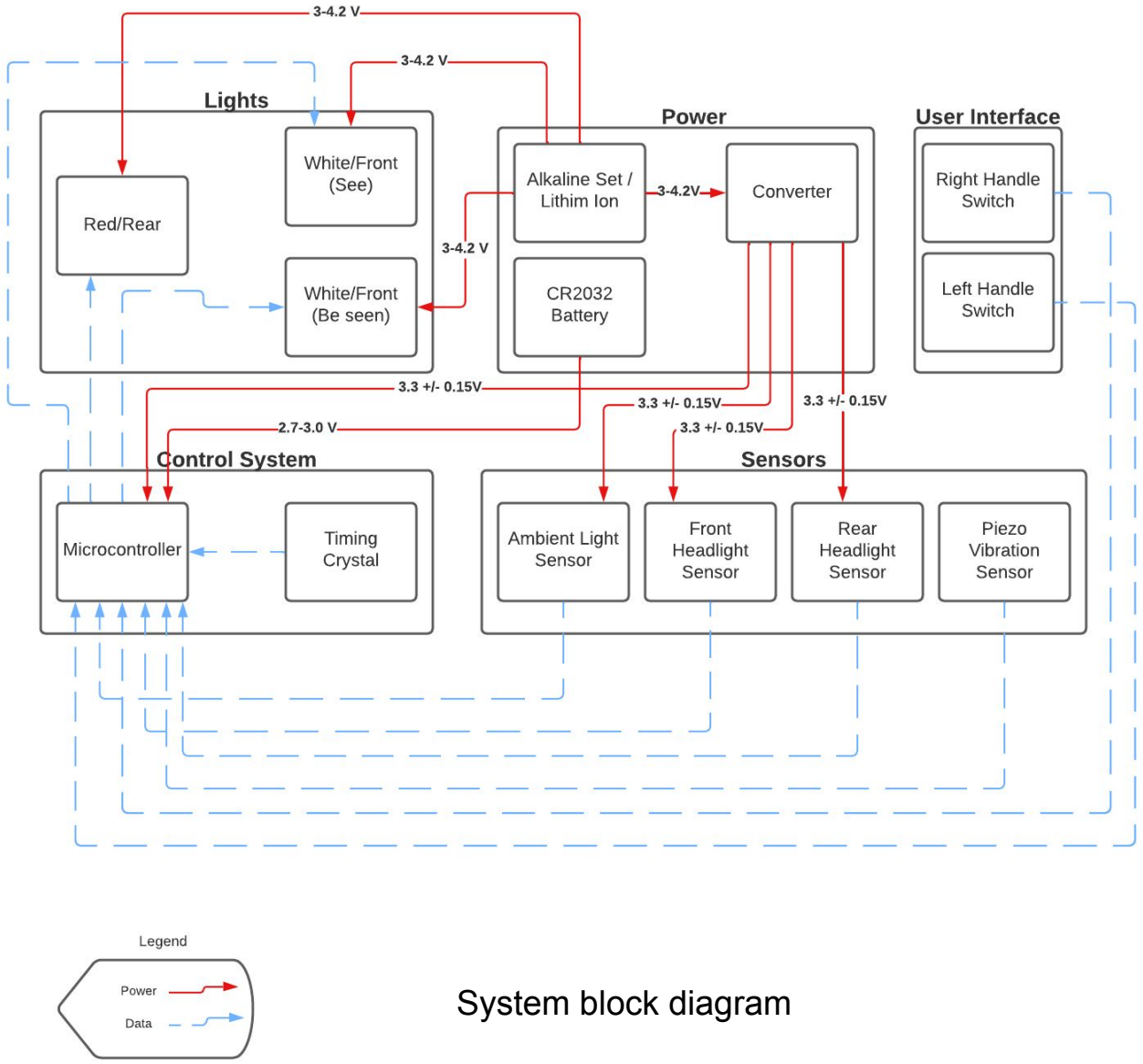
Objective

Our project seeks to improve bicyclist safety by transferring the responsibility of turning on the bike lights from the cyclist to our system.

System Requirements

- Transition from deep sleep into full operation within 15 seconds of the bicycle being in motion, and transition back to deep sleep after being stationary for 5 minutes.
- Turn on the flashing indicators when the ambient light levels fall below 500 lux for more than 10 seconds.
- Raise the brightness of the indicators if a vehicle is detected within 30 meters.
- Activate or deactivate in accordance with the user input from the left hand toggle switch.
- Turn the headlight on or off, depending on the user input from the switch on the right handlebar.

Original Design



System block diagram

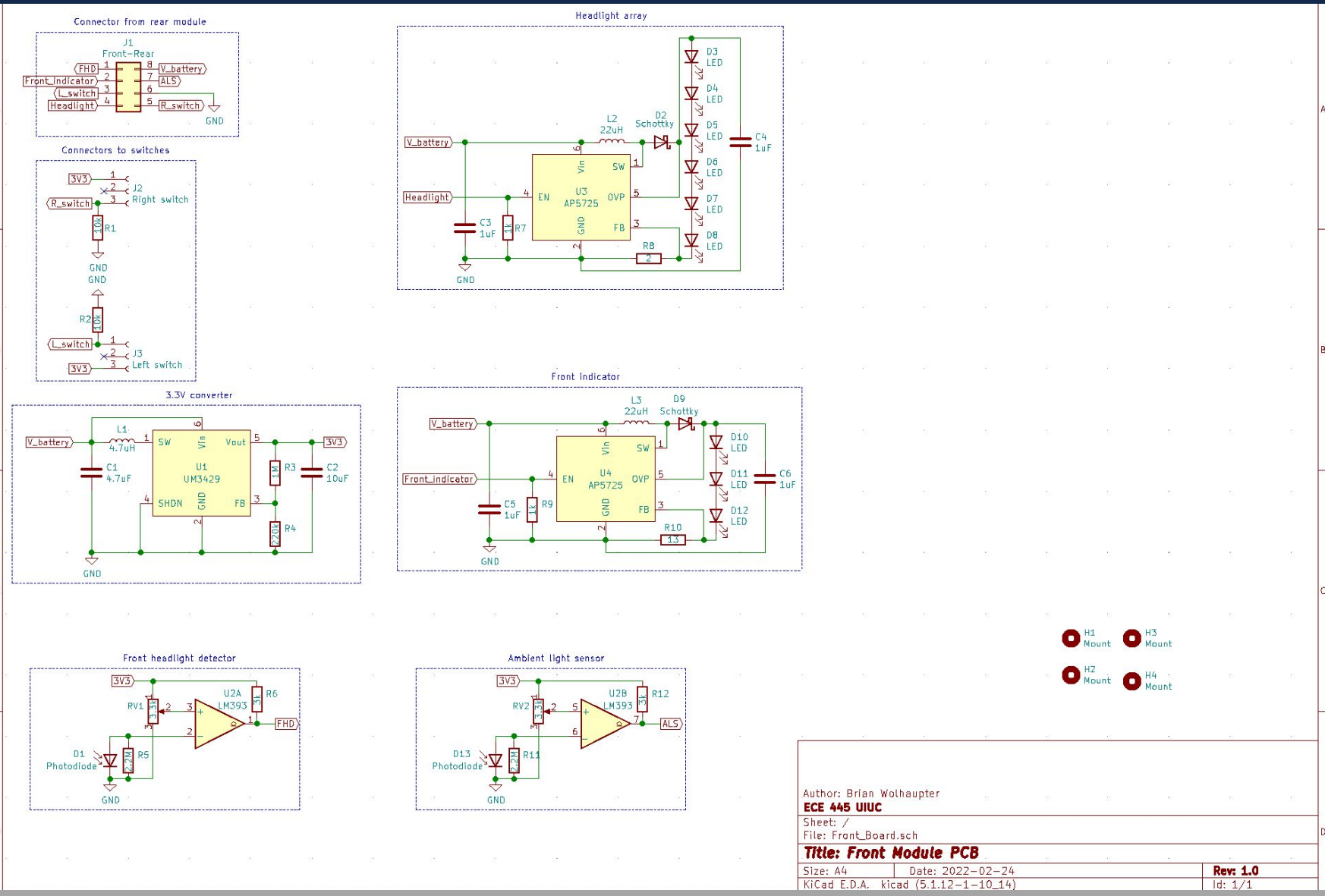
Hardware

- Power supplied by Li-ion batteries
- Front PCB mounted between the handlebars
- Rear PCB underneath the seat

Software

- Embedded C for ease of programming
- Avoid the use of analog signals to minimize impact of noise

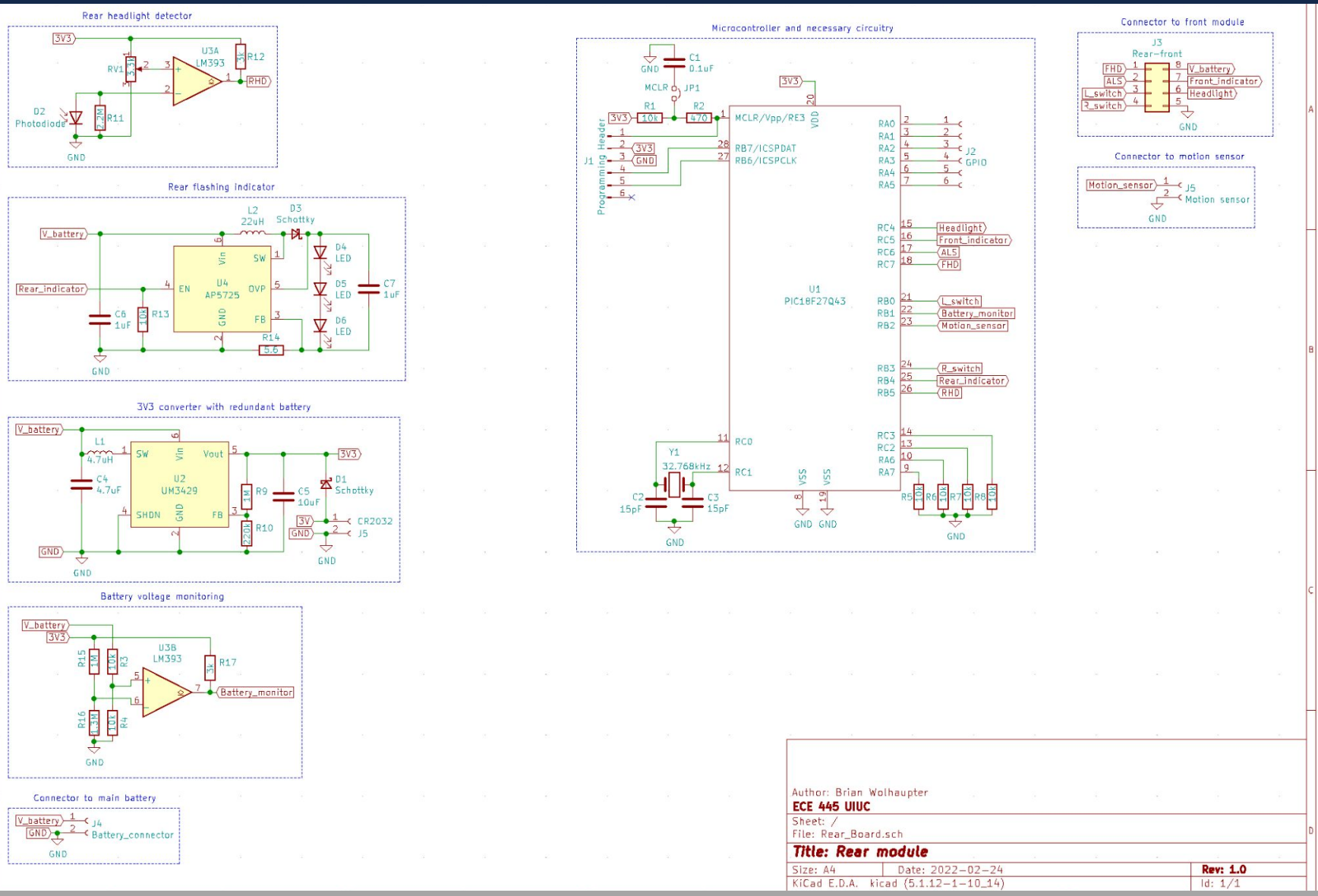
Original Design



Front Circuit Board

- Front headlight
- Front indicator
- Ambient light sensor
- Front headlight detector
- Handlebar mounted switches

Original Design

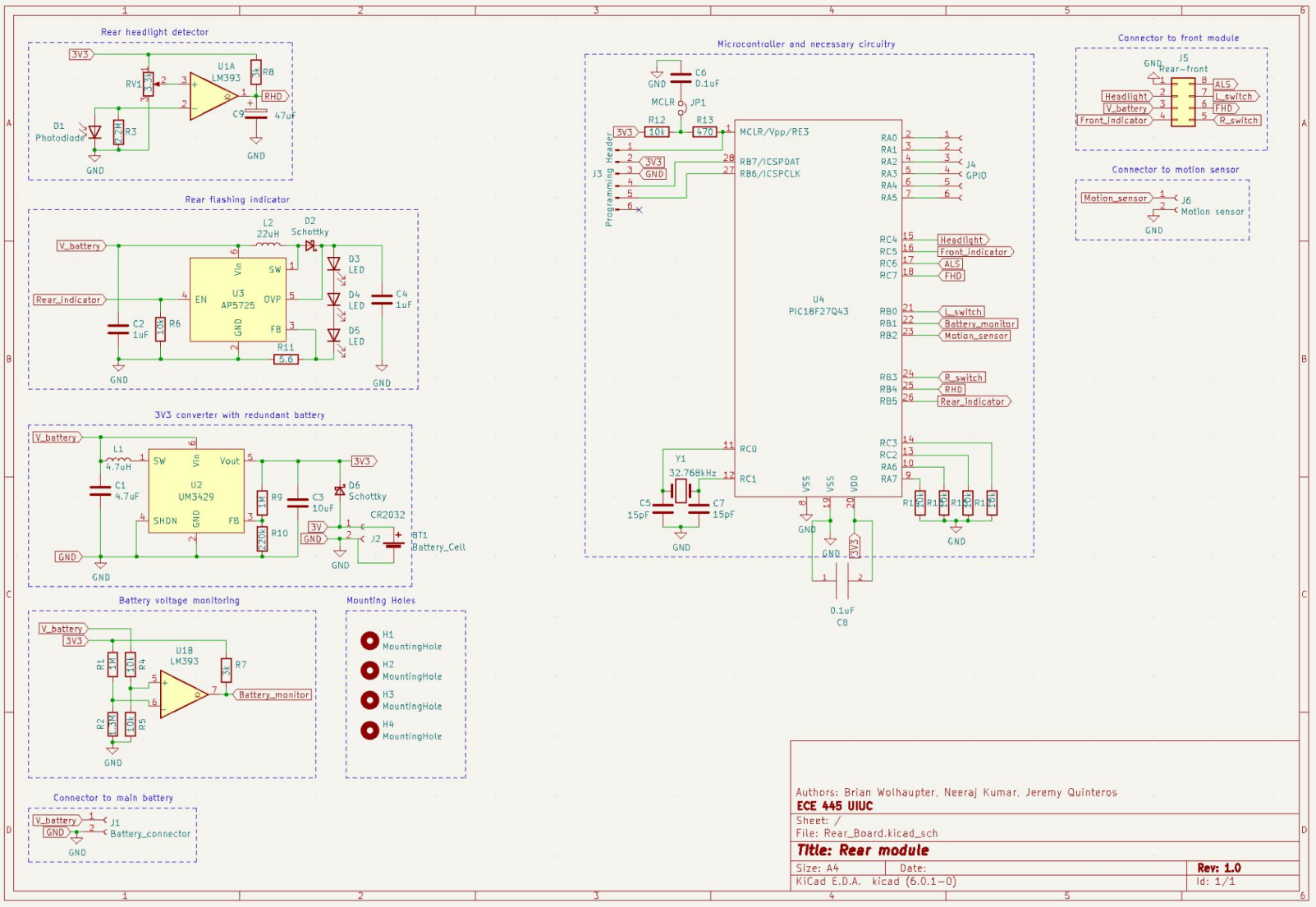


Rear Circuit Board

- Rear indicator
- Rear headlight detector
- Microcontroller
- Battery system

Rear Module

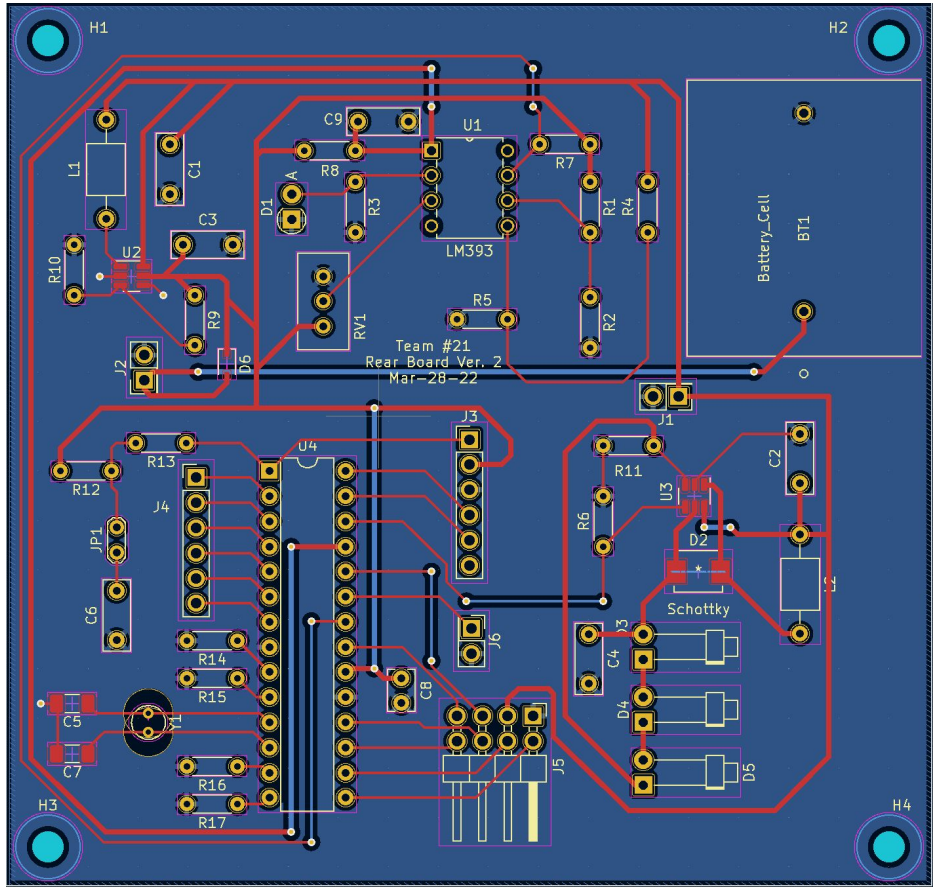
Rear Module Final Design

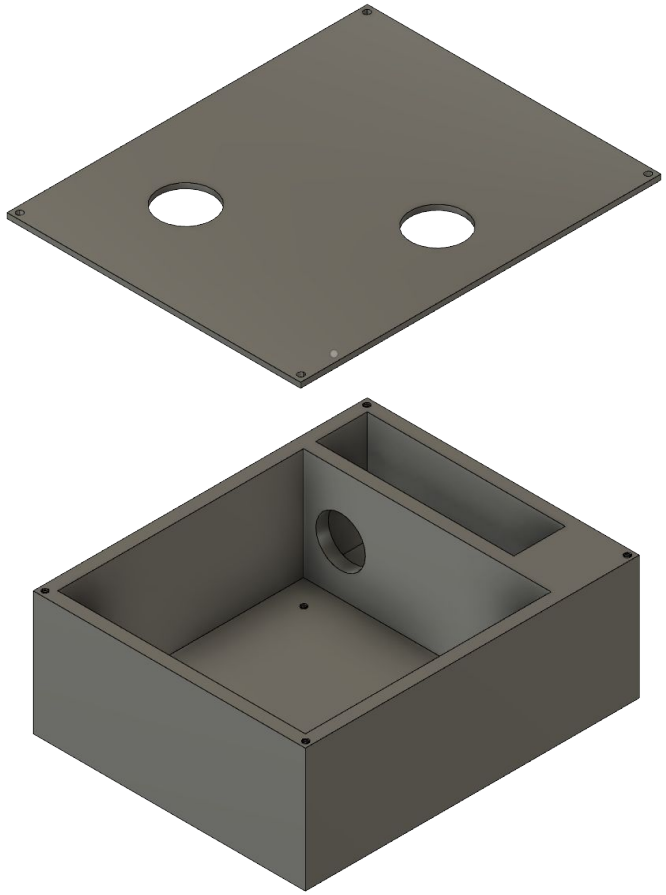


Changes

- Changed position of rear-front connection ports
- Included capacitor between microcontroller ground and Vdd in order to meet minimum requirements
- Added filtering capacitor to rear headlight detector in order to stabilize voltage
- Capacitor across LEDs connected to ground, not the negative side of the diodes.
- Added connector for CR2032 button cell battery

Rear Module Final Design





PCB Layout

- Optimized for size
- Additional components were added
- Footprints were corrected where necessary
- Layout was optimized to facilitate debugging

Enclosure

- Physically separates lithium ion battery from PCB board to protect both components from high temperatures
- Protect circuitry while maintaining apertures for lights

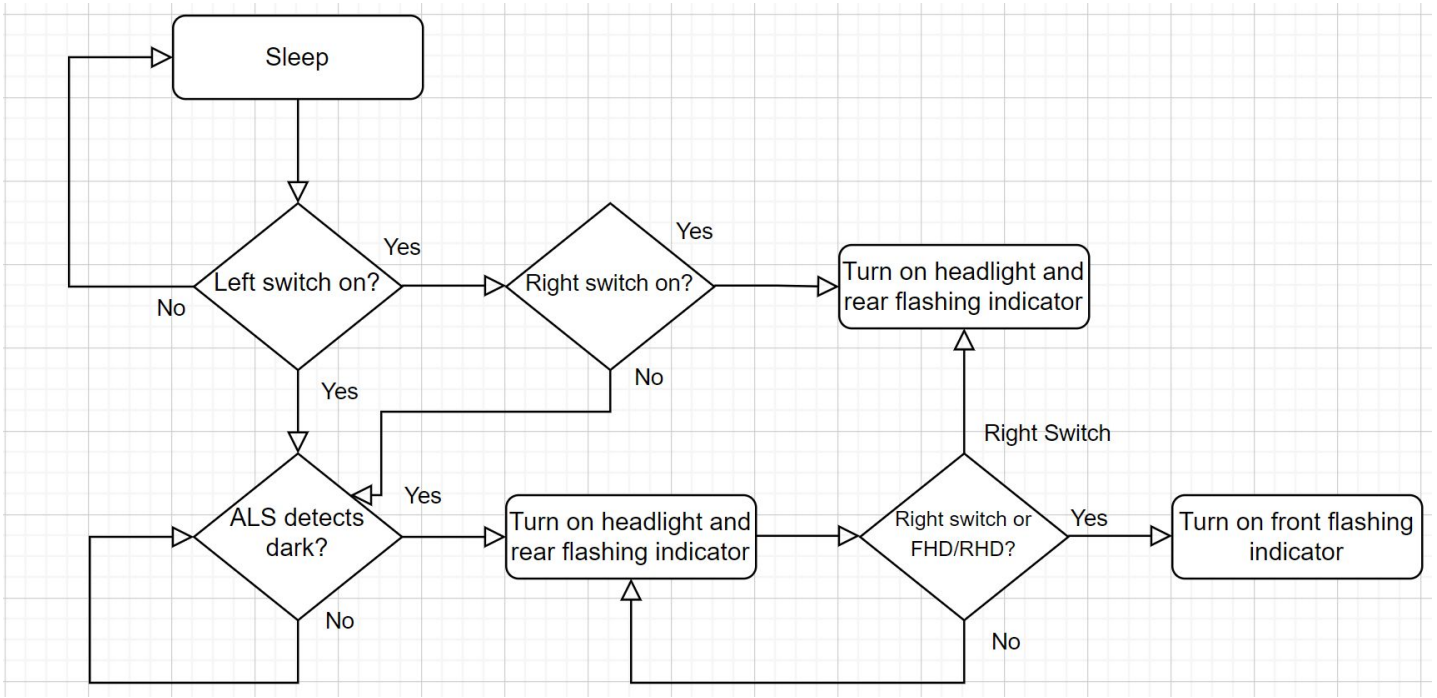
Microcontroller Programming

Microcontroller Programming

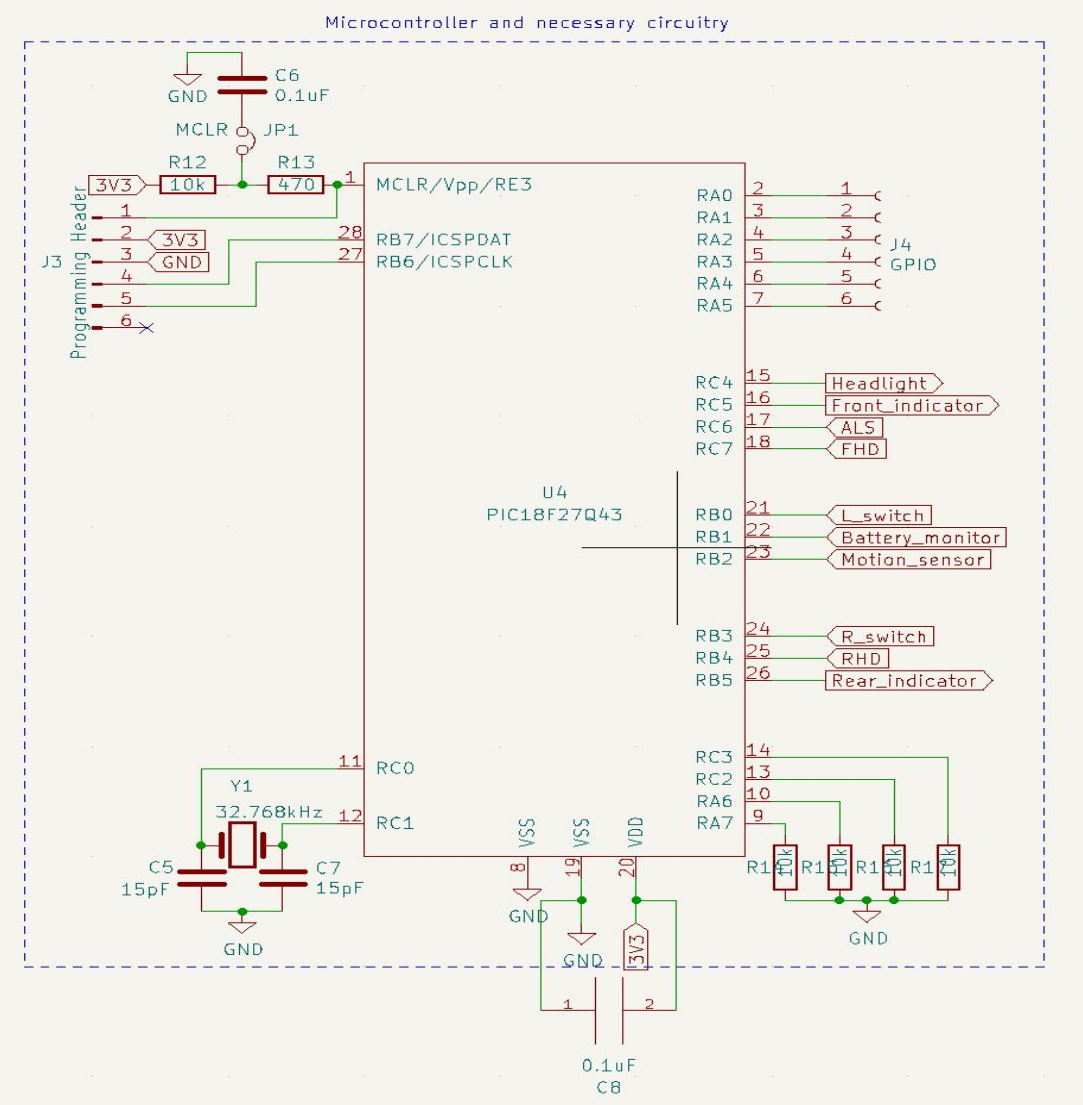
```
while(1){
    // Add your application code
    while(!L_Switch_GetValue()){ // If l_switch off, shut down then sleep
        Headlight_SetLow(); // Turn everything off
        Front_Indicator_SetLow();
        Rear_Indicator_SetLow();
        Sleep();
    }
    Front_Indicator_SetLow();
    Headlight_SetLow();
    Rear_Indicator_SetLow();
    while(ALS_GetValue()){
        Front_Indicator_SetLow();
        Headlight_Toggle();
        Rear_Indicator_Toggle();
        __delay_ms(126158);
        while(R_Switch_GetValue()){ // If right switch on, force headlight on
            Front_Indicator_SetLow(); // Turn off front indicator
            Headlight_Toggle();
            Rear_Indicator_Toggle();
            __delay_ms(126158);
        }
        while(!FHD_GetValue()){ //If FHD detects car, turn on front indicator
            Headlight_Toggle();
            Front_Indicator_Toggle();
            Rear_Indicator_Toggle();
            __delay_ms(126158);
        }
        while(!RHD_GetValue()){ //If RHD detects car, turn on front indicator
            Headlight_Toggle();
            Front_Indicator_Toggle();
            Rear_Indicator_Toggle();
            __delay_ms(126158);
        }
        while(!L_Switch_GetValue()){ // If l_switch off, shut down then sleep
            Headlight_SetLow(); // Turn everything off
```

Design Considerations

- Nested while loops allows for prioritization of signals
- Only interrupts are the left switch and battery voltage monitoring



Microcontroller Programming

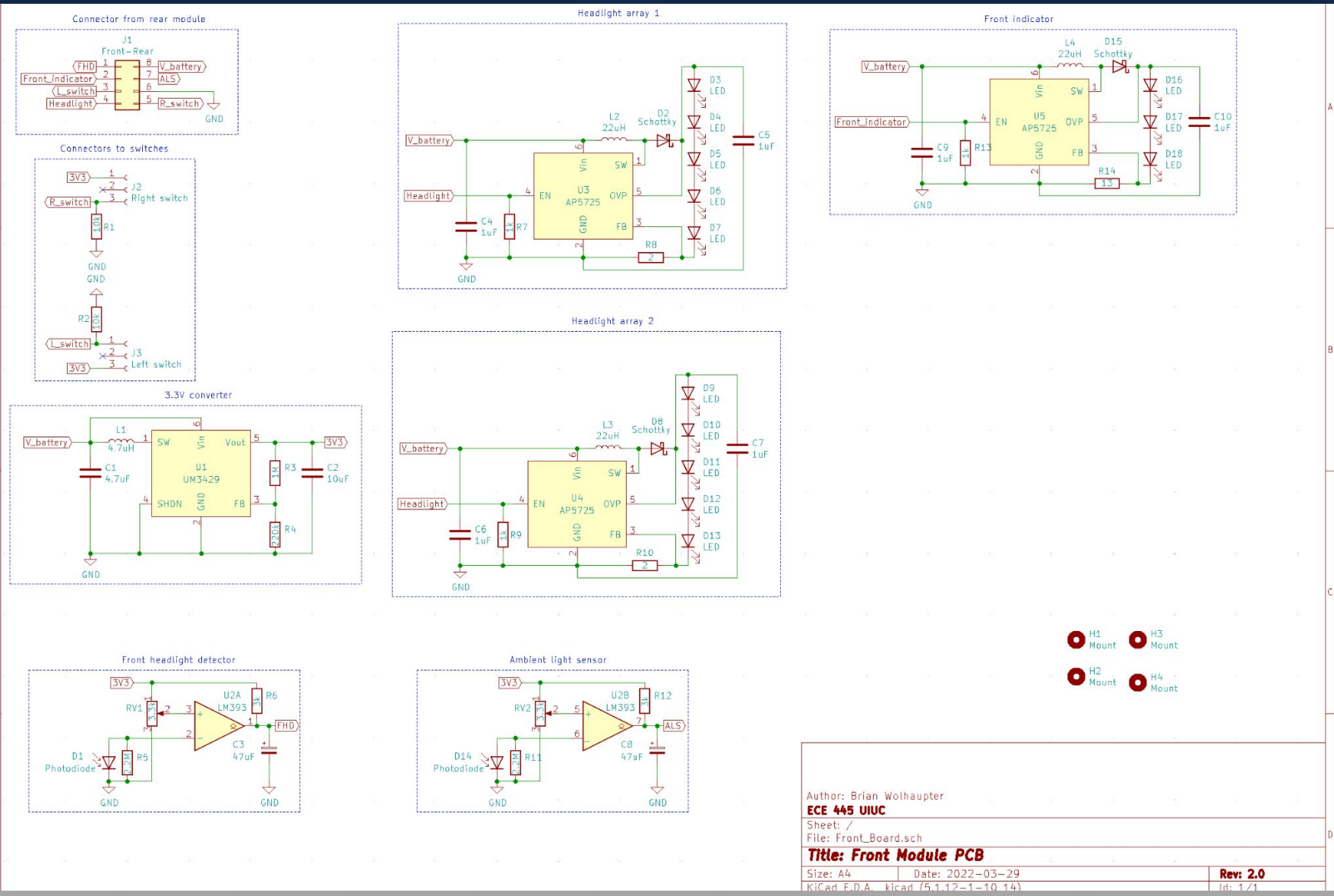


Challenges

- Incompatible programmer
- Initial first revision board power subsystem issues
- Hardware issues delayed software debugging
- Planned PWM outputs converted to GPIO

Front Module

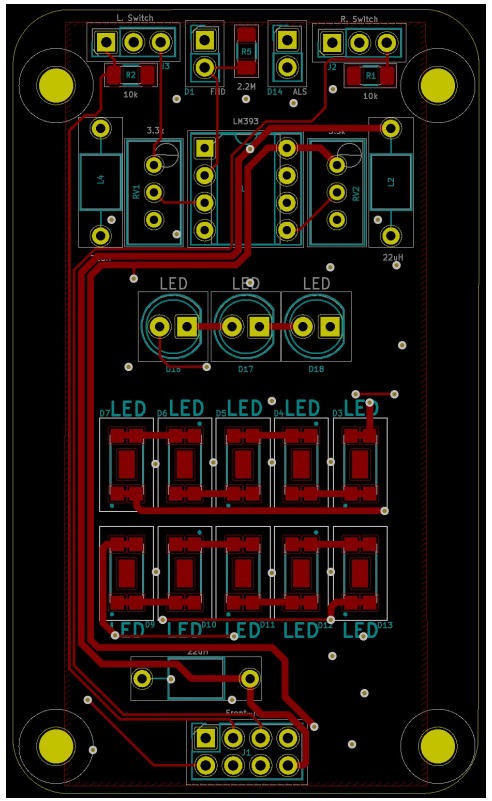
Front Module Final Design

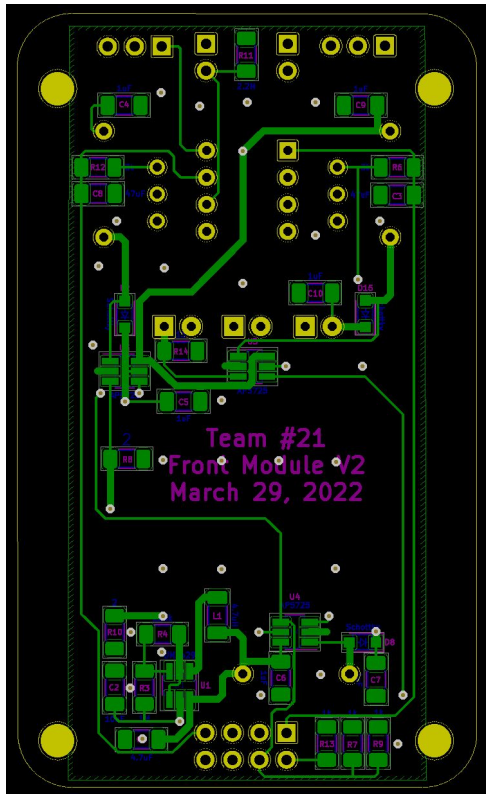


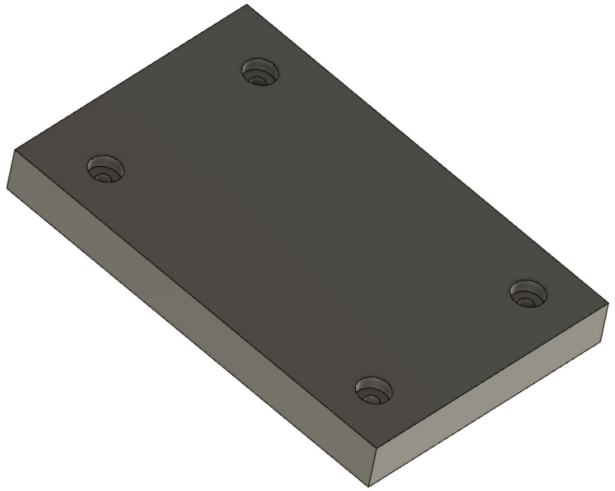
Changes from original design

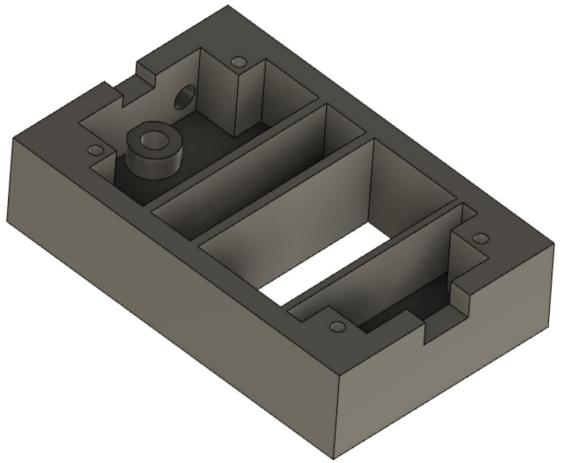
- Removed one LED from each headlight array
- Added a second headlight array
- Added filtering capacitors on the output of the light sensor circuits

Front Module Final Design









PCB Layout

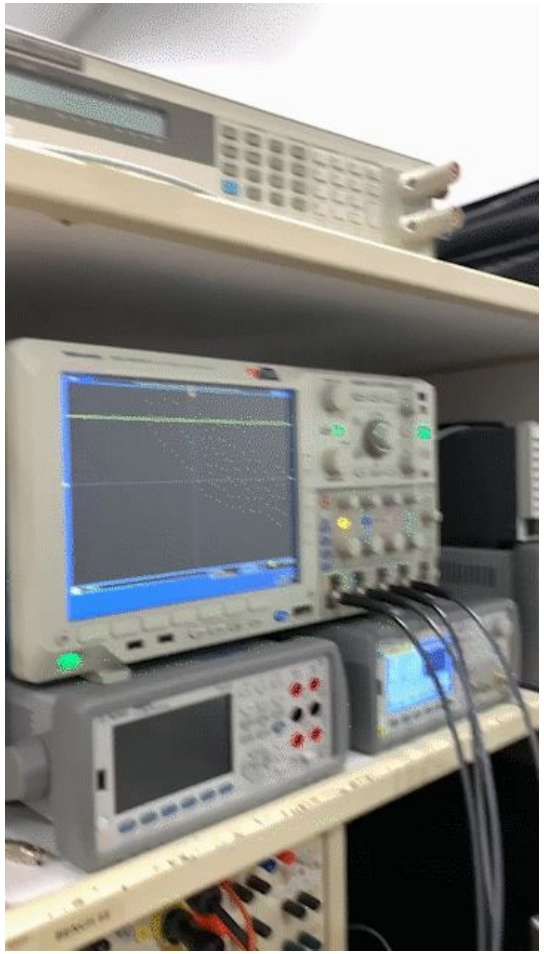
- Optimized for size
- Used both side of the board to reduce wasted space
- Surface mount components used where appropriate

Enclosure

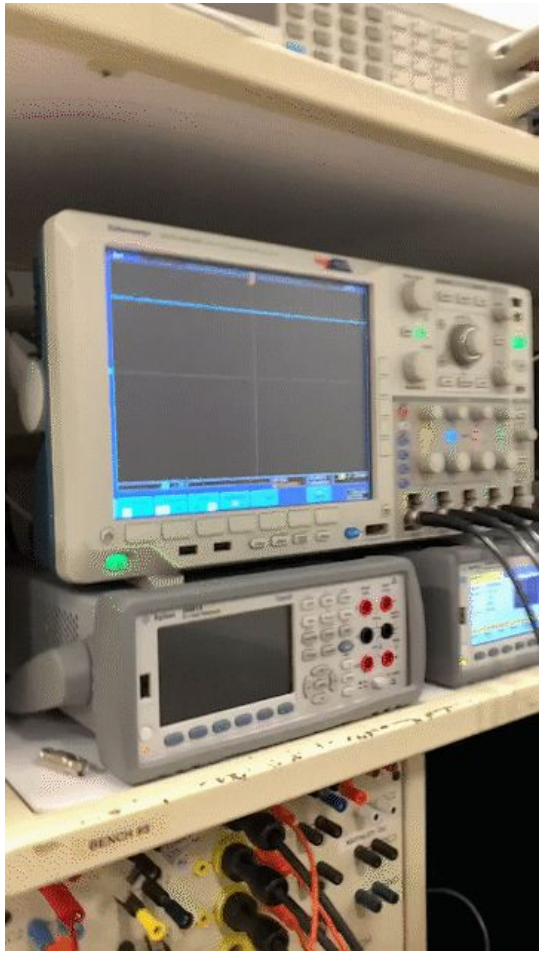
- Protect circuitry while maintaining apertures for lights and photodiodes

Project Summary and Future Work

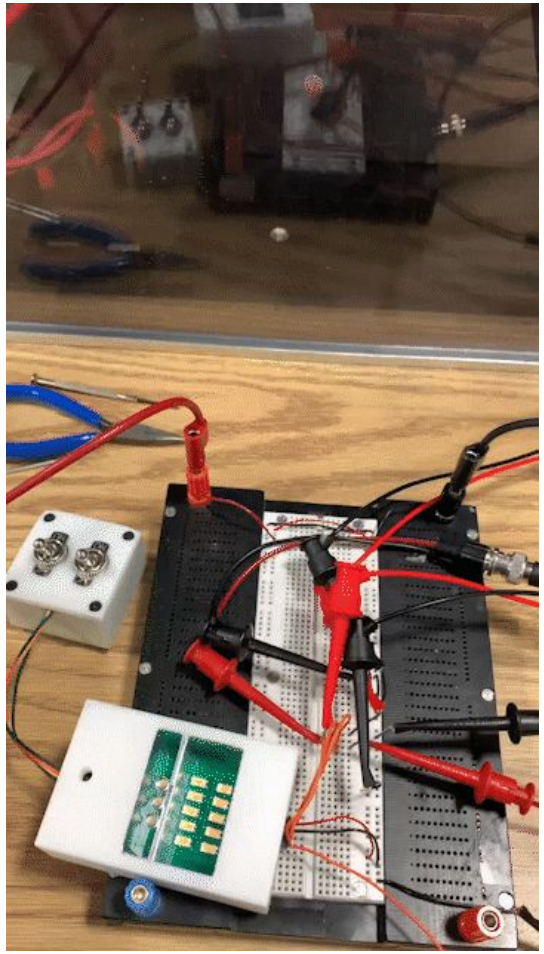
Video Demonstrations of Project Functionality



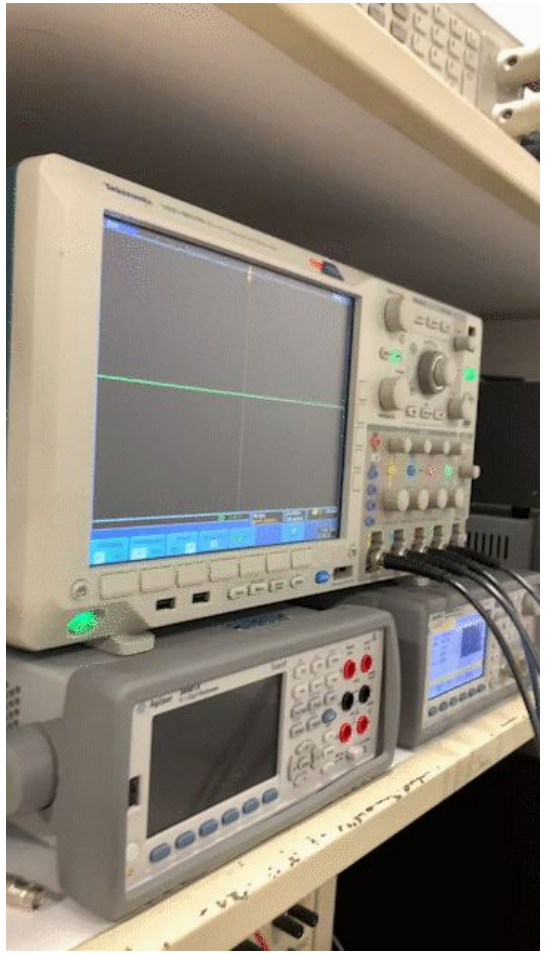
Front headlight detector toggling to logical low when headlight detected



Ambient light sensor toggling to logical low when sunlight detected

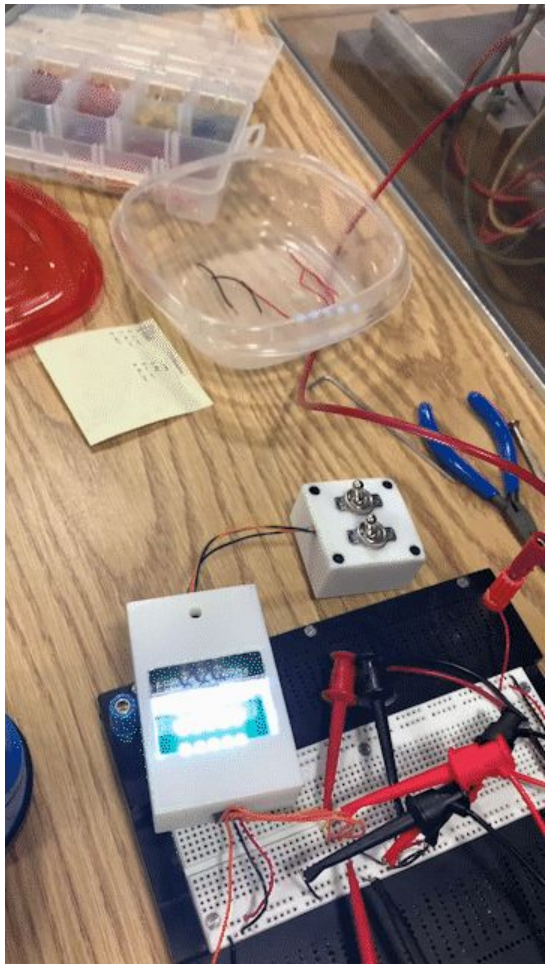


Toggling left switch

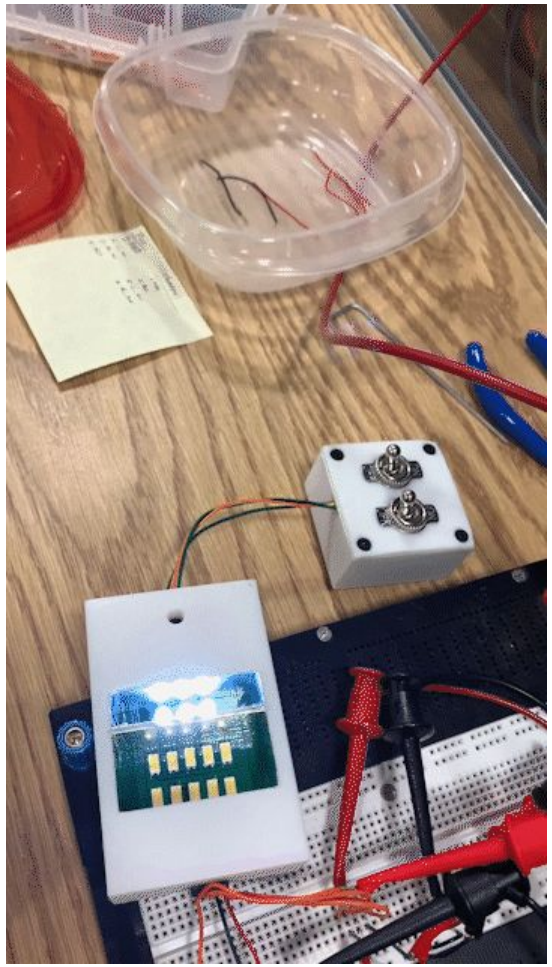


Toggling right switch

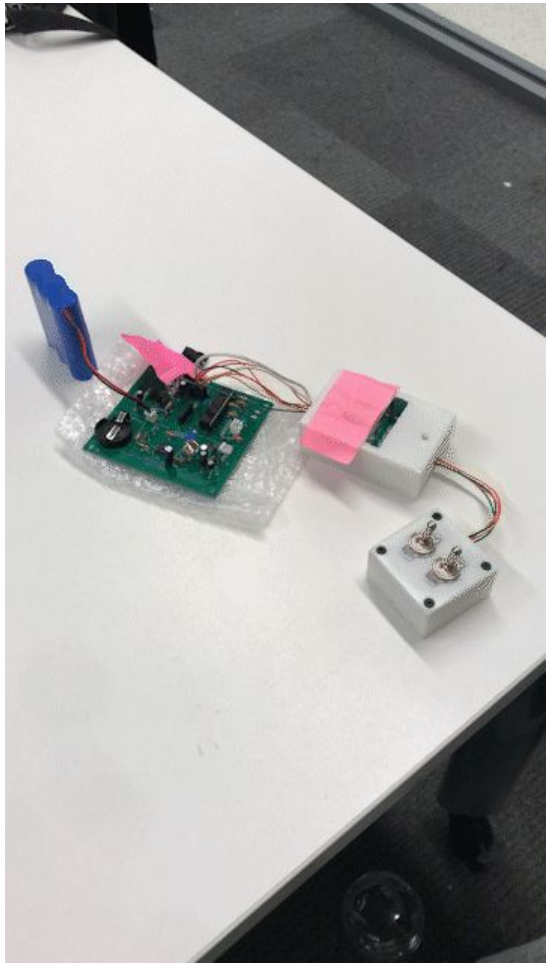
Video Demonstrations of Project Functionality



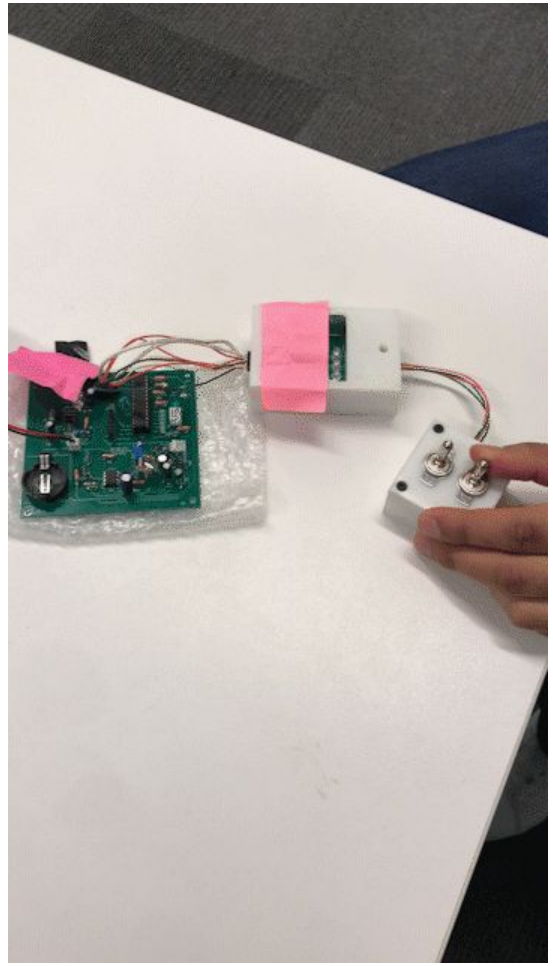
Headlight modulation



Front indicator modulation



Ambient light sensor and right switch



Front and rear headlight detector

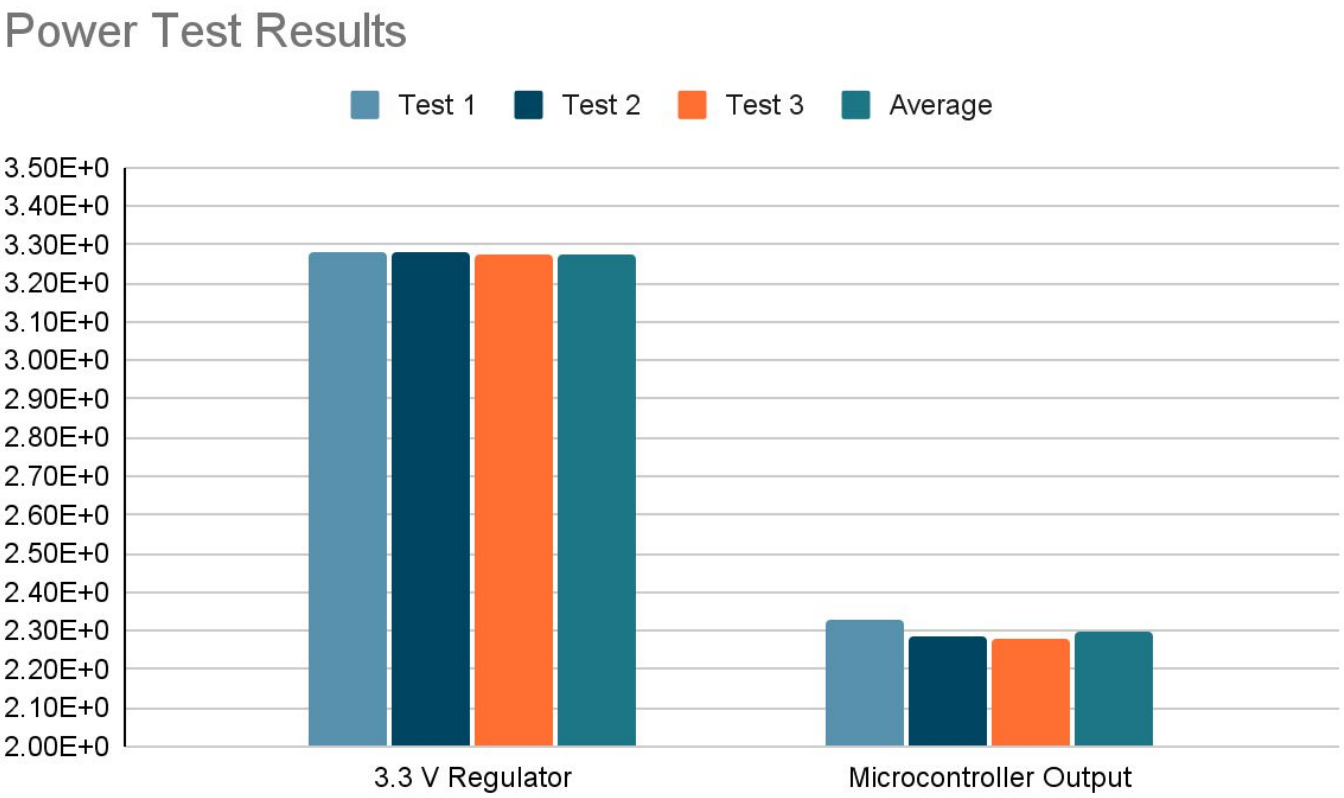
Project Summary and Future Work

Requirements	Pass/Fail
The converter must maintain an output voltage of 3.3 ± 0.15V.	Pass
Converter must not exceed 100°C	Pass
The microcontroller must maintain an output voltage greater than 1.8V, even in the event of the main battery being removed	Pass
The ambient light sensor should change its output from a logical low to a logical high when the ambient light level falls below 500 lux.	Pass
The headlight detection sensor should cause the indicator LEDs to increase in brightness if a car is detected within 30m.	Fail
The motion detection sensor should activate the system within 15 seconds of the bicycle moving	Fail

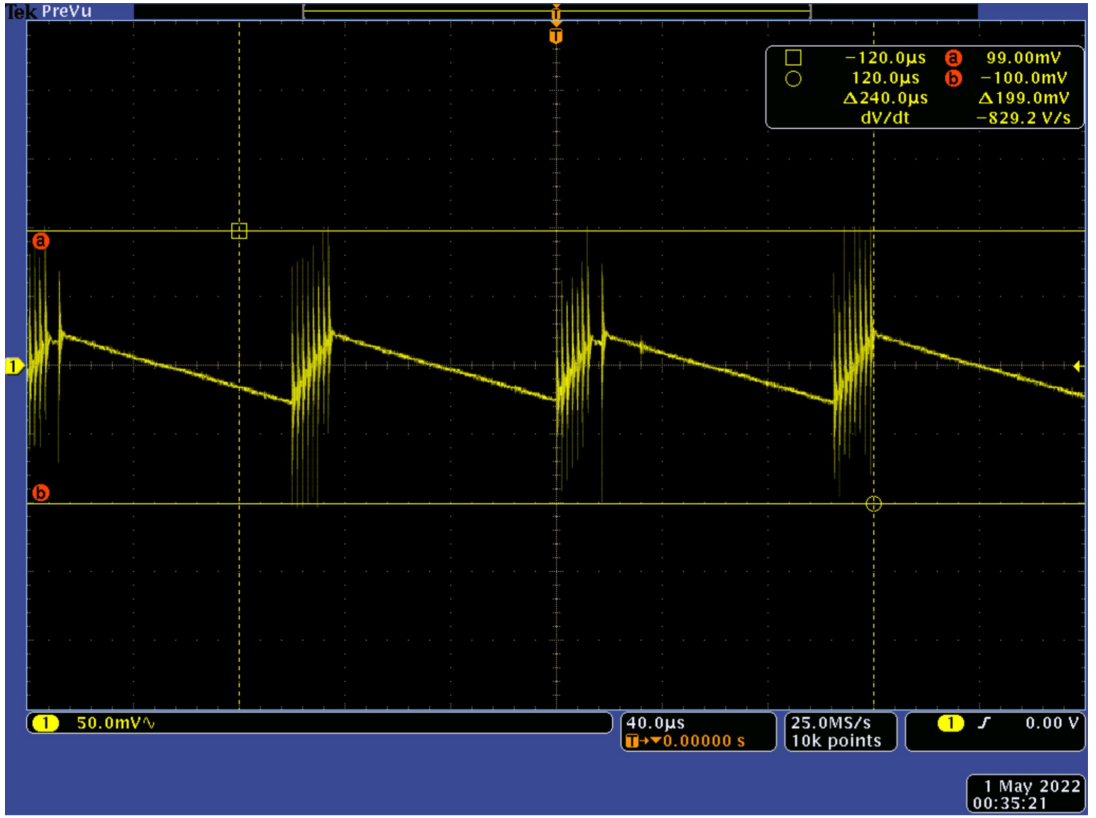
Requirements	Pass/Fail
The motion detection sensor should put the system to sleep after 30 seconds of inactivity. The actual time would be greater, but 30 seconds demonstrates the system functionality.	Fail
The left hand toggle switch should force the system to sleep, regardless of the input from the ambient light sensor.	Pass
The right hand toggle switch should turn on the headlight.	Pass
The front indicator should be visible from 30 meters away from the bike.	Pass
The rear indicator should be visible from 30 meters away from the bike.	Pass
The headlight should output enough light to measure 50 lux from 20 feet away.	Fail
The microcontroller should be able to activate all functions over which it has control.	Fail

Requirements and verification table

Project Summary and Future Work



Average output voltages of IC's



3.3V regulator output ripple

Project Summary and Future Work

Challenges

- Time
- Inexperience with PCB layout
- Component availability
- Programming the microcontroller

Future Work

- Finish programming PWM features
- Find a new solution for motion detection
- Manufacture housing for the rear PCB
- Improve the front PCB housing

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