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
Front Circuit Board
- Front headlight
- Front indicator
- Ambient light sensor
- Front headlight detector
- Handlebar mounted switches
Rear Circuit Board
- Rear indicator
- Rear headlight detector
- Microcontroller
- Battery system
Rear Module
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
**Design Considerations**

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

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Pass/Fail</th>
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<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>The converter must maintain an output voltage of 3.3 ± 0.15V.</td>
<td>Pass</td>
<td>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.</td>
<td>Fail</td>
</tr>
<tr>
<td>Converter must not exceed 100°C</td>
<td>Pass</td>
<td>The left hand toggle switch should force the system to sleep, regardless of the input from the ambient light sensor.</td>
<td>Pass</td>
</tr>
<tr>
<td>The microcontroller must maintain an output voltage greater than 1.8V, even in the event of the main battery being removed</td>
<td>Pass</td>
<td>The right hand toggle switch should turn on the headlight.</td>
<td>Pass</td>
</tr>
<tr>
<td>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.</td>
<td>Pass</td>
<td>The front indicator should be visible from 30 meters away from the bike.</td>
<td>Pass</td>
</tr>
<tr>
<td>The headlight detection sensor should cause the indicator LEDs to increase in brightness if a car is detected within 30m.</td>
<td>Fail</td>
<td>The rear indicator should be visible from 30 meters away from the bike.</td>
<td>Pass</td>
</tr>
<tr>
<td>The motion detection sensor should activate the system within 15 seconds of the bicycle moving</td>
<td>Fail</td>
<td>The headlight should output enough light to measure 50 lux from 20 feet away.</td>
<td>Fail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The microcontroller should be able to activate all functions over which it has control.</td>
<td>Fail</td>
</tr>
</tbody>
</table>
Project Summary and Future Work

Power Test Results

- Test 1
- Test 2
- Test 3
- Average

- 3.3 V Regulator
- Microcontroller Output

Average output voltages of IC’s

3.3V regulator output ripple
Challenges
- Time
- Inexperienced 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