Bicycle Automated Turn Signal (BATSignal)

Natalya Bapst (bapst2)
Bora Cukurova (cukurov2)
Hanna Zayed (jhzayed2)

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TA: Zipeng Wang

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# Table of Contents

1. **Design** ......................................................................................................................................... 3  
   1.1 Block Diagram .......................................................................................................................... 3  
   1.2 Block Description – Gyroscope & Accelerometer .................................................................... 3  
2. **Schematic, Calculation, and Plot** ............................................................................................... 4  
   2.1 Schematic .................................................................................................................................... 4  
   2.2 Calculation ................................................................................................................................. 5  
   2.3 Plot ............................................................................................................................................. 6  
3. **Requirements and Verifications - Sensors** ............................................................................... 6  
4. **Safety Statement** ....................................................................................................................... 7  
5. **Citations** ..................................................................................................................................... 7
1. Design

1.1 Block Diagram

![Block Diagram Image]

1.2 Gyroscope/Accelerometer

The InvenSense MPU-6050 chip will be used for this portion of the design. The chip includes both a 6 axis gyroscope as well as an accelerometer. The accelerometer will be used to determine the tilt angle (how much the cyclist leans to the side) of the bike during a turn. It will also be used to determine when the cyclist is braking. The accelerometer x-axis will be placed along the bike, z-axis going up, y-axis to the left. When the cyclist leans to the left or right, its y-axis and z-axis will change, indicating that the cyclist is making a turn. As the cyclist deaccelerates, the x-axis will increase in the negative x direction indicating a brake. The gyroscope will determine the rotation of the front wheel. It will be used to convert the angular position of the wheel and handlebars to digital code to be used by the microcontroller to determine if a turn has been completed. This chip has an operating voltage of 2.375 - 3.46 V.
2. Schematic, Calculation and Plot

2.1 Schematic

Partial PCB Layout (Microcontroller, Gyroscope, Accelerometer, Regulator):

Microcontroller – ATMEGA328-PU
2.2 Calculation

This calculation serves to determine the amount of power required for the back-end device we plan to mount on the rear of the bicycle. The components of this back-end device are the following: (1) the LED board, (2) the RF receiver, and (3) the battery, which will provide the power. Thus, calculating the power required involves determining the power used by the LEDs and the RF receiver.

**Power Required for LEDs:**

The red LEDs will be “ULTRA-BRITE RED LED T-1 3/4 125MCD, 626NM”, which is part number 08R2970 from the supply center. The yellow LEDs will be “ULTRA BRIGHT YELLOW LED 10CD 589NM, 2.1V”, which is part number 14N9429 from the supply center.

The red LEDs each have a power dissipation of 130 mW. We will use 9 red LEDs.

The yellow LEDs each have a power dissipation of 85 mW. We will use 14 yellow LEDs.

We will drive each of these LEDs with a 220 Ω resistor. The resistor we will use from the parts shop is a 220 Ω, ¼ W resistor. At this point, we can calculate the total power required by the LED board, as follows:

\[
P_{\text{tot,LED}} = N_{\text{res}}P_{\text{res}} + N_{\text{red}}P_{\text{red}} + N_{\text{yet}}P_{\text{yet}} = 23(0.25 W) + 9(0.13 W) + 14(0.085 W) = 8.11 W
\]

**Power Required for Receiver:**

For the receiver, we will use the LINX LR receiver module, which has part number RXM-315-LR.

From the data sheet, we gather that the maximum operating voltage is 3.6 VDC and the maximum supply current is 7.0 mA. Thus, we can say that the maximum operating power of this chip will be as follows:

\[
P_{\text{tot,RX}} = (3.6 V)(7.0 mA) = 25.2 mW
\]

**Total Power:**

We can finally calculate the total power required for the back-end device as follows:

\[
P_{\text{total}} = P_{\text{tot,LED}} + P_{\text{tot,RX}} = 8.11 W + 25.2 mW = 8.1352 W
\]
2.3 Plot

The following plot graphs the distance standing from LEDs on a bike to a brightness factor recorded and averaged with three separate persons. Three amounts of LEDs were tested, 10 LEDs, 15 LEDs, and 20 LEDs. It can be seen that more LEDs equates to better visibility from a distance, however there is not much of an increase after 15 LEDs are used.

3. Requirements and Verifications

3.1 Sensors

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
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<tbody>
<tr>
<td>1. Accelerometer can detect a resolution range of -30 to 30 m/s² acceleration</td>
<td>1. We will measure the RPM of the bicycle wheel by calculating the speed and angle down a hill to derive acceleration</td>
</tr>
<tr>
<td>2. It can detect when the cyclist is braking</td>
<td>2. The sensor could detect the cyclist braking for 80% of 100 tests</td>
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Gyroscope can detect a minimum turn angle of the handlebars of 30 degrees

1. Use a protractor/angle gauge on the ground along the y axis to measure the angle of the front wheel and verify that 30 degrees is the minimum detected

Gyroscope can detect a minimum tilt angle of the entire bike when the cyclist leans of 10 degrees

1. Use a protractor/angle gauge on the ground along the x axis to measure the angle of the bicycle tilt and verify that 10 degrees is the minimum detected

4. Safety Statement

One danger posed by our design is the use of a Lithium Ion Battery. This battery often is unstable and can sometimes overheat or create an explosion. In order to combat this possibility, we propose to use an Internal Protection Lithium Ion Battery which has internal regulations for ensuring the safety of the battery for the user.

5. Citations


