Mock Design Review: EBS (Electronic Bike Shifting)

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ECE 445

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1. Block Diagram

![Block Diagram](image1)

2. Circuit Schematic

![Circuit Schematic](image2)

Circuit diagram for the accelerometer.
3. Calculation

Calculating maximum battery life while holding position in one gear ratio:

The stall torque at 4.8 V is 15.5 kgf cm, drawing 4 mA. Thus the power consumption for this stall torque is:

\[
P_{\text{stall torque}} = VI = (4.8 \, V)(4 \, mA) = .0192 \, W
\]

Assuming a capacity of 620 mAh for an average rechargeable lithium-ion 9V battery, we find:

\[
battery \, capacity = 9 \, V \frac{620 \, \text{milliamp \, hour}}{\text{battery}} = 5.58 \, W \, hr \, \text{battery}
\]

This means, that together, we can power a sustained gear ratio for:

\[
battery \, life = \frac{battery \, capacity}{P_{\text{stall torque}}} = 290.625 \, \text{hour \, battery}
\]
4. Plot (simulation or experiment)

Below are two plots of accelerometer data attached to the rear derailleur.

A plot of the X-axis of the accelerometer with the X-axis perpendicular to the bicycle and pointing toward the derailleur.
A plot of the X-axis of the accelerometer with the X-axis parallel to the bicycle and along side the derailleur.

For the first plot, we shifted every 100 time units or so without a noticeable difference in the data whereas for the second plot, the shifts are very noticeable. In hindsight, considering how the accelerometer works, it makes senses as to why the first orientation generated useless data while the second one generated rather nice results; however, there is still a lot of noise at each gearing which will be further worsened by the introduction of road noise. We also noticed a correlation between pedal acceleration and noise levels in the graphs.
5. Block description

Shifting system microcontroller: The microcontroller sends movement commands to the servo, and interprets the accelerometer data to confirm successful shifts. It will also deal with system initialization and calibration. The microcontroller will be connected to a communication module which will provide communication abilities. When the microcontroller receives a press event from the communication module, it moves up or down a gear by rotating a servo. To determine when to stop rotating the servo, the microcontroller interprets incoming accelerometer data to detect the peaks and valleys expected with mid-shift. The microcontroller may need to ignore road noise and potholes. When the peaks and valleys end, the microcontroller stops rotating the servo and considers the gear shift done. Initially we intend on using an Arduino but will upgrade to something smaller and more power efficient. Our final microcontroller should draw less than 100 mA.

6. Requirements & Verifications for shifting system microcontroller

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
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<tbody>
<tr>
<td>1) Draws less than 100 mA</td>
<td>1) Measure the input current when the microcontroller is fully under load.</td>
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<tr>
<td>2) Digital I/O functions correctly</td>
<td>2) For outputs, blink an LED and verify that it corresponds to correct state in software</td>
</tr>
<tr>
<td>3) Packets are sent and received within half a second from initiation</td>
<td>For inputs, toggle a switch and verify that the 0 V and 5 V are correctly interpreted.</td>
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7. Safety statement

Our electronic gear shift system has two major components that present a safety hazard: the two batteries and the servo/derailleur system.
The system is not currently designed to be waterproof or water-resistant. Do not operate bikes outfitted with our system while it is raining or drizzling. Avoid puddles, streams, and bodies of water while riding. When cleaning the bike, avoid contacting any component of the gear shifting system with water.

Use the same precautions as you would when operating a normal bicycle, such as not placing any part of your body in contact with parts or chains that are moving at high speed.

Do not attempt to rotate the servo by hand while the system is powered on. Do not put any part of your body near the derailleur, derailleur cable, or servo, as these may suddenly change in position while the system is powered on.

The gear shifting system uses two batteries: one to power the buttons at the front of the bike, and one to power gear shifts on the back wheel. These batteries should be handled with caution:

- Do not charge batteries beyond their maximum safe voltage or their maximum safe current
- Do not operate the system when the batteries are below their minimum safe voltage
- Do not draw more current than the batteries are designed to provide
- Do not charge the batteries outside of their safe charging temperatures
- Do not short circuit the batteries
- Do not immerse the batteries in water or get them wet
- Connect the batteries with correct polarity. Do not reverse the battery connections.
- Do not leave the batteries in an area with an excessively high temperature
- Before using our system, inspect the batteries for damage or irregularities
Be properly trained with lab safety and electrical safety before working with or maintaining our system.