Dynamo LED Bike
Safety Lights

Mock Design Review
ECE 445

Group 13: Lee Gill, Isabel Martin, & Gregory Plauck
TA: Jackson Lenz

February 17, 2016
Table of Contents

1. Block Diagram
2. Circuit Schematic
3. Calculations
4. Plots
5. One Block Description
   5.1. Power Supply
6. Requirements and Verification
7. Safety Statement
8. Citations
1. Block diagram
2. Circuit Schematic

![Buck Converter Schematic](image)

Figure 1: Buck Converter Schematic

3. Calculations

In order to determine the inductor size for our AC-DC buck converter we needed to determine the duty ratio range, load current, and maximum ripple current. Because our input is expected to range from 12-24 Vrms AC, the ideal duty ratio to obtain a 7.5 V output will be:

\[ D = \frac{V_{out}}{V_{in}} \quad D_{\text{max}} = 7.5 \times \frac{12}{24} = 0.442 \quad \text{and} \quad D_{\text{min}} = 7.5 \times \frac{24}{24} = 0.221 \quad (1) \]

The load current for a 6 W load, which is the maximum that the dynamo can supply will be 67.5 = 0.8 A. Next we will choose our ripple current, \( \Delta I_{L_{pk}} \), to be less than 0.2 A such that our converter will stay in continuous conduction mode. Now, the inductor size for the worst case scenario of a 33.94 V input and 0.221 duty ratio will be:

\[ L = D(1-D)V_{in} \Delta I_{L_{pk}} \quad \Delta I_{L_{pk}} = 0.221(1-0.221)33.94 \times 2(150 \times 10^3) = 194 \mu H \quad (2) \]

From the inductor ripple current, the output capacitor can be calculated such that the peak to peak ripple voltage is no greater than 0.2 V.

\[ C_{out} = \Delta I_{L_{pk}} \Delta V_{fsw} = 0.28(0.2)(150 \times 10^3) = 0.833 \mu F \quad (3) \]

4. Plots

Figure 2 shows the inductor ripple current. The peak to peak ripple current is 0.175 A which is less than the 0.2 A assumption in equation (2).
Figure 2: Inductor Ripple Current

Figure 3 shows the output voltage ripple simulation which should be between 7.3 and 7.5 V. Clearly the lower bound is exceeded by about .04 V and some additional changes may be required to meet these specifications.
Figure 3: Output voltage ripple
5. One block description

5.1. Power supply

A bike dynamo will be used as the source of generation in our design. This dynamo is rated for up to 6 W and outputs two AC voltages, 12 VAC (rms) and 3.4 VAC (rms). Some online research suggested the dynamo may output an AC voltage as high as 24 Vrms (this will be tested ASAP). Thus, our power supply will include an AC/DC converter that will accept any AC voltage in the range of 12-24 Vrms generated by the dynamo. The converter will output a DC voltage of 7.4 V and will power the lights as well as charge a supercapacitor bank.

6. Requirements and verifications for one module from the block diagram

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AC/DC converter</td>
<td>Verification process for item 1:</td>
</tr>
<tr>
<td>I. Input is 12-24 Vrms AC and output is 7.4 V +/- 0.1 V DC at 0.8 A</td>
<td>a. Attach 9.375 Ω load resistor</td>
</tr>
<tr>
<td></td>
<td>b. Attach oscilloscope across load</td>
</tr>
<tr>
<td></td>
<td>c. Sweep voltage from 12-24 Vrms AC</td>
</tr>
<tr>
<td></td>
<td>d. Use 150 kHz gate driver with adjustable duty cycle (due to variable input) to drive MOSFET and obtain 7.5 V DC</td>
</tr>
<tr>
<td></td>
<td>Ensure voltage remains between 7.3 and 7.5 V</td>
</tr>
</tbody>
</table>

7. Safety statement

- Double-check your wiring and circuit connections. It is a good idea to use a point-to-point wiring diagram to review when making these checks.

- Apply low voltages or low power to check proper functionality of circuits.

- No loose wires or metal pieces should be lying on table or near the circuit, to cause shorts and sparking.

- Check if you have connected load at the output.

- Power down the circuit before making changes.
8. Citations
