SMART HIGHWAY LIGHTPOSTS

PROJECT PROPOSAL

TA: ANKIT JAIN
ECE 445
Kevin Obrzut
Maria del Carmen Alvarez

February 10, 2016
# Table of Contents

1.0 Introduction ......................................................................................................................... 3
  1.1 Statement of Purpose .......................................................................................................... 3
  1.2 Objectives ........................................................................................................................... 3
    1.2.1 Goals and Benefits ...................................................................................................... 3
    1.2.2 Functions and Features .............................................................................................. 3

2.0 Design .................................................................................................................................. 4
  2.1 General block diagram of a single module ......................................................................... 4
  2.2 Block diagrams of central control circuits ........................................................................ 4
    2.2.1 Power Source ............................................................................................................. 4
    2.2.2 Microcontroller ......................................................................................................... 4
    2.2.3 Receiver .................................................................................................................... 4
    2.2.4 Transmitter ............................................................................................................... 5
  2.3 Block Diagram of Sensor Circuit ...................................................................................... 5
    2.3.1 Power Source ............................................................................................................. 5
    2.3.2 Microcontroller ......................................................................................................... 5
    2.3.3 Receiver .................................................................................................................... 5
    2.3.4 Ultrasonic Sensor ...................................................................................................... 5
  2.4 Block Diagram of Light Control Circuit ............................................................................ 6
    2.4.1 Power Source ............................................................................................................. 6
    2.4.2 Microcontroller ......................................................................................................... 6
    2.4.3 Receiver .................................................................................................................... 6
    2.4.4 LEDs ....................................................................................................................... 6

3.0 Requirements and Verification .......................................................................................... 7

4.0 Cost and Schedule ............................................................................................................. 8
  4.1 Cost Analysis ..................................................................................................................... 8
    4.1.1 Labor ......................................................................................................................... 8
    4.1.2 Cost of parts per module .......................................................................................... 8
  4.2 Schedule ............................................................................................................................ 9
1.0 Introduction

1.1 Statement of Purpose

Excess amount of highway light posts being lit contributes to excessive energy consumption, large costs, and a lot of money is wasted on keeping highway lights lit. There are too many light posts turned on in highway areas where not a single car is driving through. Our solution are smart highway light posts. Our solution aims to save energy, decrease costs and contribute to dark skies.

1.2 Objectives

1.2.1 Goals & Benefits

• Energy usage reduction.
• Cost reduction.
• Contribution to dark-sky movement.

1.2.2 Functions and Features

• Compute speed of cars passing by.
• Determine density of cars passing by.
• Determine which lane each car is driving through.
• Decide which light posts should be turned on or off and for how long.
• Determine amount of surrounding light to turn whole system on or off
2.0 Design

2.1 General Block Diagram of a single module

![General Block Diagram of a module and the separate circuits used.](image)

The way we have designed this project uses three different types of circuits. There are four separate sensor circuits which use ultrasonic sensors to determine the volume and velocity of passing cars. This data is then sent to the central control circuit, which analyzes this data and then transmits a turn on/off signal to each of the four light control circuits. Block diagrams for each circuit is shown in sections 2.2-

2.2 Block Diagrams of Central Control Circuit

![Central Control Circuit. Orange lines represent power and black are for signals.](image)

2.2.1. Power Source
This is our power supply to the circuit. We plan on using a 5V power source using a battery.

2.2.2. Microcontroller
This is the main microcontroller for each module. This micro controller will take in data from the photonic sensor as well as the data from the receivers on the chip. The data will then be interpreted and sent to the transmitter to transmit signals to the light control circuits.

2.2.3. Receiver
This section contains four receivers, one for each of the ultrasonic sensors. These receivers accept signals from a corresponding transmitter on one of the sensor circuits.
2.2.4 Transmitter
This section contains our 8-channel transmitter. With these 8 channels, we are able to communicate to up to eight different receivers (i.e. light control circuits).

2.3 Block Diagram of Sensor Circuit

![Sensor Control Circuit Diagram]

Figure 2. Sensor Control Circuit. Orange lines represent power and black are for signals.

2.3.1. Power Source
This is our power supply to the circuit. We plan on using a 5V power source using a battery which delivers a 25mA current.

2.3.2. Microcontroller
This is the microcontroller for each sensor. This microcontroller will take in data from the photonic sensor. The data will then be sent to the transmitter to transmit signals to the main control circuit.

2.3.3 Transmitter
This section contains our transmitter. With these 8 channels, we are able to send signals to one of the receivers on the central control circuit.

2.3.4. Ultrasonic sensor
This section contains our ultrasonic sensor, these sensors have a range of up to 26 feet and can detect if an object is in its path. This is used to determine if there is a car in the lane in front of the sensor.
2.4 Block Diagram of Light Control Circuit

2.4.1. Power Source
This is our power supply to the circuit. We plan on using a 5V power source using a battery which delivers a 25mA current.

2.4.2 Microcontroller
This is the microcontroller for each LED set. This micro controller will take in data from the receiver. Depending on the signal sent, the LED system will either turn on/off.

2.4.3 Receiver
This section contains one receiver, one for the corresponding ultrasonic sensor. This signal will either be a turn-on or turn-off signal for the LED system.

2.4.3. LEDs
This section contains a set of several LEDs which are lit when the microcontroller tells them to do so. This is done to simulate a light post.
### 3.0 Requirements and Verification

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
</tr>
</thead>
</table>
| **1. Ultrasonic sensors**  
1) Detects objects within specified range. And are within ±5ft accuracy.  
2) Operating range of 4.5V+ 0.25V. Doesn’t exceed 5.5V (Max voltage)  
3) Doesn’t exceed 2Ma current (Max current) | 1) Connect the ultrasonic sensor to the microprocessor. Then analyze input data to determine the determined distance. Correct determined distance if different from actual distance by adding code.  
2) Measure the voltage in parallel using an oscilloscope and make sure the voltage swing is less than 0.25V. Measure the current in series again using an oscilloscope and make sure the peak amplitude doesn’t exceed the max current. **For steps 2-3: The same process is used for determining the voltage and current limits for the rest of the parts.** |
| **2. Light Sensor**  
1) Detects change in illuminance.  
2) Operating range of 4.5V+ 0.25V. Doesn’t exceed 6V (Max voltage)  
3) Doesn’t exceed 20mA current (Max current) | 1) Fix the voltage at 5V using a power supply. Then determine if there is a change in current due to the detected illuminance using a DDM. Change illuminance by changing brightness of room.  
2) Test current and voltage with oscilloscope. **|
| **3. Receiver**  
1) Detects an incoming signal.  
2) Each channel can accept a signal  
3) Can receive a signal within 0.5 miles  
4) Operating range of 4.5V+ 0.25V. Doesn’t exceed 5.3V (Max)  
5) Doesn’t exceed 13mA (Max) | 1) Make sure the receiver is connected to a microcontroller and a transmitter to one as well. Ensure a link is connected with one transmitter. Send a turn LED-on signal from transmitter using a microcontroller. If the Receiver accepts the signal, have it light an LED in a different I/O pin on.  
2) Repeat step 1, but this time use all 8 channels to check all channels.  
3) Repeat step 1, but this time spread the receiver and transmitter to ~0.5 miles apart.  
4-5) Test current and voltage with oscilloscope.** |
| **4. Transmitter**  
1) Sends a signal.  
2) Each channel can send a signal  
3) Can receive a signal within 0.5 miles  
4) Operating range of 4.5V+ 0.25V. Doesn’t exceed 5.3V (Max)  
5) Doesn’t exceed 13mA (Max) | 1) Make sure the receiver is connected to a microcontroller and a transmitter to one as well. Ensure a link is connected with one transmitter. Send a turn LED-on signal from transmitter using a microcontroller. If the Receiver accepts the signal, have it light an LED in a different I/O pin on.  
2) Repeat step 1, but this time use all 8 channels to check all channels.  
3) Repeat step 1, but this time spread the receiver and transmitter to ~0.5 miles apart.  
4) Test current and voltage with oscilloscope. **|
| **5. Microcontroller**  
1) Properly sends and receives data.  
2) Obtains sensors and receivers data correctly | 1) Attach LEDs to selected output pins and program the microprocessor to send a high voltage signal to the selected I/O ports.  
2) Compare the read current values from the sensors and compare with the determined values in the microcontroller. |
6) **Power Supply**  
1) Have a voltage of 4.5 +/- 0.25 V. The current must not exceed 100mA.  

1) Test this output voltage using an oscilloscope to determine the variation is within our limits.  
2) Use a oscilloscope to determine the output current through a resistor.

4.0 Cost and Schedule  
4.1 Cost Analysis  

4.1.1 Labor  

<table>
<thead>
<tr>
<th></th>
<th>Hours of Work</th>
<th>Hiring</th>
<th>Hourly Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kevin Obrzut</td>
<td>260</td>
<td>X 2</td>
<td>$30.00</td>
<td>$15,600</td>
</tr>
<tr>
<td>Carmen Alvarez</td>
<td>260</td>
<td>X 2</td>
<td>$30.00</td>
<td>$15,600</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>520</strong></td>
<td>--</td>
<td><strong>$60.00</strong></td>
<td><strong>$31,200</strong></td>
</tr>
</tbody>
</table>

4.1.2 Cost of Parts – Per Module  

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
<th>Individual Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller- PIC16F877A</td>
<td>9</td>
<td>$5</td>
<td>$45</td>
</tr>
<tr>
<td>Receiver- RXM-900-HP3-PPS</td>
<td>9</td>
<td>~$5</td>
<td>$45</td>
</tr>
<tr>
<td>Transmitter- TXM-900-HP3-PPS</td>
<td>5</td>
<td>~$5</td>
<td>$25</td>
</tr>
<tr>
<td>Light Sensor- TEPT5700</td>
<td>1</td>
<td>$1</td>
<td>$1</td>
</tr>
<tr>
<td>Ultrasonic Sensor- maxSonar MB10400</td>
<td>4</td>
<td>$30</td>
<td>$120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>~$240</td>
</tr>
</tbody>
</table>
## 4.2 Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Task</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Feb</td>
<td>Finish project proposal.</td>
<td>Carmen, Kevin.</td>
</tr>
<tr>
<td>15-Feb</td>
<td>Work on design review</td>
<td>Kevin</td>
</tr>
<tr>
<td></td>
<td>Work on eagle review</td>
<td>Carmen</td>
</tr>
<tr>
<td>22-Feb</td>
<td>Laboratory safety training</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td></td>
<td>Work on soldering assignment</td>
<td>Carmen</td>
</tr>
<tr>
<td></td>
<td>Start working on design review</td>
<td>Kevin</td>
</tr>
<tr>
<td>29-Feb</td>
<td>Specify sensors, transmitters.</td>
<td>Carmen</td>
</tr>
<tr>
<td></td>
<td>Specify microcontrollers and receivers.</td>
<td>Kevin</td>
</tr>
<tr>
<td></td>
<td>Continue working on design review.</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>7-Mar</td>
<td>Purchase any necessary components.</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>14-Mar</td>
<td>Run tests on components.</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td></td>
<td>Program sensors module 1,2,3</td>
<td>Kevin</td>
</tr>
<tr>
<td></td>
<td>Program central module 1,2,3</td>
<td>Carmen</td>
</tr>
<tr>
<td>21-Mar</td>
<td>Run tests on sensors-central microcontroller interaction</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>28-Mar</td>
<td>Program light posts module 1</td>
<td>Carmen</td>
</tr>
<tr>
<td></td>
<td>Program light posts module 2,3</td>
<td>Kevin</td>
</tr>
<tr>
<td>4-Apr</td>
<td>Run tests on light posts-central microcontroller interaction</td>
<td>Carmen</td>
</tr>
<tr>
<td></td>
<td>Run tests on whole system</td>
<td>Kevin</td>
</tr>
<tr>
<td>11-Apr</td>
<td>Prepare mock demonstration</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>18-Apr</td>
<td>Prepare mock presentation</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>25-Apr</td>
<td>Run tests on final project</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td></td>
<td>Prepare final demonstration</td>
<td>Carmen, Kevin</td>
</tr>
<tr>
<td>2-May</td>
<td>Prepare final presentation</td>
<td>Carmen</td>
</tr>
<tr>
<td></td>
<td>Prepare final papers</td>
<td>Kevin</td>
</tr>
<tr>
<td>9-May</td>
<td>Lab checkout</td>
<td>Kevin</td>
</tr>
<tr>
<td></td>
<td>Review final paper</td>
<td>Carmen</td>
</tr>
</tbody>
</table>