High efficient stand-alone Streetlamps

Team 11: Xiaolou Huang, Patrick Wang, and Collin Hasken
ECE 445 Proposal - Fall 2017
TA: Kexin Hui

1. Introduction

1.1 Objective

Our goal is to design a stand alone streetlight that will power itself through sunlight (Solar Power) and store the energy for later use (at night). Lithium-ion batteries will power LED lights that can produce 3000+ lumen. Battery status and customization will be available through a mobile app on a bluetooth connected smartphone.

1.2 Background

In some area in the US/around the world it is difficult to have the access to the power grid. It would be inefficient to pull a power line across an entire region to power up a few street lights. Furthermore, during natural disasters, such as hurricanes, the power is often cut in a region, and essential streetlights will stop functioning at night. An independent, stand-alone streetlight that extracts and stores solar energy in a battery to power the light bulb will fix these problems.

1.3 High-level Requirements List

- Lithium-Ion Battery Capacity (>60Ah)
    - Needs to operate two consecutive nights without any input pow
- Average daily input power from power panel at least (400Wh, 33.3Ah)
- Solar Panel & Battery costs must be reduced to minimum

2. Design

2.1 Block Diagram

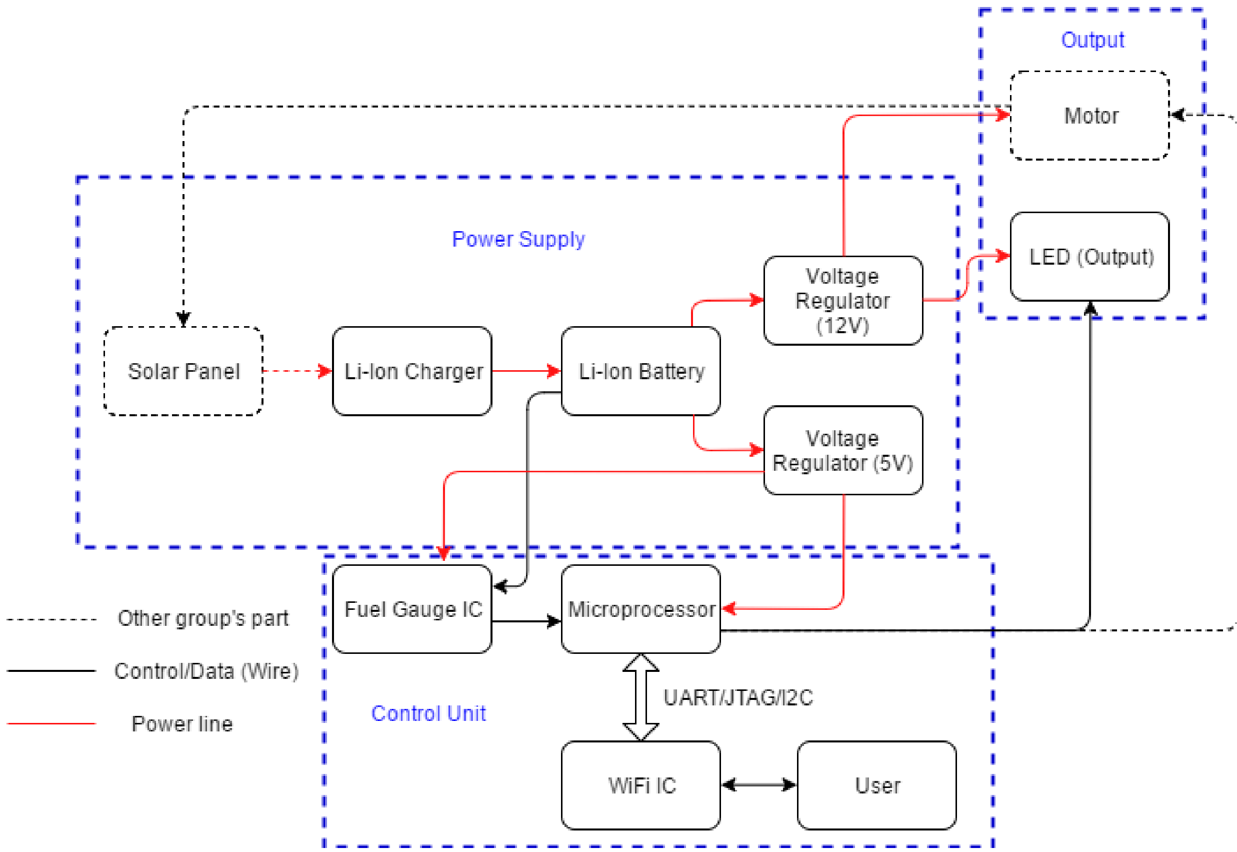

Figure 2.1 Block Diagram

2.2 Block Diagram Description

The solar panel will receive power to charge the lithium ion battery. The battery will supply power to a 12V voltage regulator that will power the LED light as well as the motor that tilts the solar panel. The battery will also supply power to a 5V voltage regulator to a microprocessor, charge gauge, and WiFi IC. The microprocessor will receive input from the charge gauge and WiFi IC and output to the LED to control when to turn on and off and to the WiFi IC to update the user with the battery charge.

2.3 Power Supply

2.3.1 Solar Panel

The source of input power; this is a fundamental component in the project as it extracts solar energy and gives the power through the charger to the batteries. The size & weight of the Solar Panel must be fitting to be mounted on a street lamp. Due to adjustable angles for the solar panels that will be provided from another group, the size can be significantly reduced. Average power generated per day should be at least 400Wh.

2.3.2 Lithium-ion Charger

This IC will be used specifically for charging Lithium-ion batteries, as different type of batteries have different charging properties. It will receive an unsteady input voltage (due to variation solar intensity) and charge the batteries. Input voltage/current of the charger should have a high range.

2.3.3 Lithium-ion Battery

Where the energy is stored and used for the output (LED) and motors. The battery should have a nominal voltage of roughly 7.4V (2 cells) or 11.1V (3 cells). Battery capacity should be at least 60Ah, and maximum acceptable charging current should be roughly 0.25C.

2.3.4 Voltage-regulators (Boost/Buck converters)

The input voltage of the LED is 12V and the input voltage for the microprocessor is 5V. We need the regulators to step-up the battery voltage to 12V and step-down to achieve 5V.

2.4 Output

2.4.1 LED (load)

Power consumption should be roughly 35-40 W; and needs to produce a minimum of 3000 lumens. Multiple LED could be used.

2.5 Control Unit

2.5.1 Microprocessor

The microprocessor will be powered by the battery; it will control/communicate with the wifi module. It will also read the data from the fuel gauge, and has the ability to turn on or shut off the LED (load).

2.5.2 Fuel Gauge

The fuel gauge will read the battery voltage, measures the capacity (through coulomb counter), etc. and send the data to the microprocessor. This will also be powered by the battery.

2.5.3 WiFi-module

Query and send the charging status of the battery. Receive commands to switch between different power modes and setting schedule, which will be delivered to the micro controller.

2.6 Risk Analysis

The capacity for the battery needs to be large enough to reach the requirement of 60Ah; the physical size and stress due to weight of the large battery will have on the lamps. The tolerance for the component won't be significant if we have a battery capacity at i.e. 70Ah, since the more capacity the better.

2.7 Requirements

2.7.1 WiFi-module

Requirements	**Verifications**
1. Send messages up to 50 meters 2. Receive messages up to 50 meters	

2.7.2 Li-ion Battery

Requirements	**Verifications**
1. Capacity of 60 Ah+ 2. Maximum charging current to be 0.2C	

(12A) and equivalent discharging current	

2.7.3 LED Output

Requirements	Verifications
1. Output 3000+ lumen 2. Input Voltage of 12V, Power consumption 35-40 W 3. Either internal or external switch (togglable)	

2.7.4 Voltage Regulator (12V)

Requirements	Verifications
1. Input voltage range from 5-15V. 2. Regulate voltage from battery voltage to 12V (boost converter) 3. Maximum output current must be at least 3A	

2.7.5 Voltage Regulator (5V)

Requirements	Verifications
1. Input voltage range from 5-15V 2. Regulate voltage from battery voltage to 5V (buck converter)	

2.7.6 Microprocessor

Requirements	Verifications
1. Enough GPIO to have communication with fuel gauge, Wifi-IC, relays for switches, etc. 2. At least 10 MB of internal flash to store temporary data.	

2.7.7 Fuel Gauge IC

Requirements	Verifications
1. Should accept an input Voltage of 5V 2. Send battery capacity and other information status to the microprocessor through I2C or 1-Wire. 3. Current counter/not voltage reader for measuring battery capacity	

2.7.8 Charger IC

Requirements	Verifications
1. Charge the battery only when in safe temperature range: a. Stop charging when temperature is above 45 degree Celsius or below 0 degree Celsius 2. Maximum charging current should be 12 A. Input voltage should range from 0 V - 24 V 3. Designated to charge Li-Ion Battery, CCCV	

3 Ethics and Safety

3.1 Ethics

“1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;”[1]

With our project, we are charging and discharging a battery. This introduces a potential danger of the battery explosion or expelling acid. For this reason, we will show warnings for any danger and accept responsibility for our choices.

“3. to be honest and realistic in stating claims or estimates based on available data;”[1]

We will not over promise on our light output or how long the light can stay on.

“4. to reject bribery in all its forms;”[1]
We will not accept bribery from other groups working on the same problem to allow their projects to be better than ours.

“7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;”[1]
We will ask our TA for assistance whenever we are unsure to make sure we aren’t putting anyone at risk.

3.2 Safety

Our largest safety concern is with our battery. Batteries store large amount of chemical energy, especially in our project, a size of 60Ah can cause extreme heat which could cause fire if the battery is internally or externally shorted. We plan to use two series and multiple in parallel to achieve this capacity. Nominal voltage will be roughly 7.4 V, and shorting this voltage could generate a very high current.
Operational wise, we want to prevent damage to the battery and other potential hazards by stopping the charging or discharging of the battery when it is outside of the regulated temperatures. For lithium-ion batteries, this is between 0 - 45 degrees celsius for charging and -20 to 60 degrees celsius for discharge.[2]
User wise, our safety concern is making sure the final streetlight is bright enough to light up the ground as required and the ability to provide light throughout the night.

4 Citations and References

[1] Ieee.org, "IEEE IEEE Code of Ethics", 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 19- Sept- 2017].

[2] “Charging at High and Low Temperatures”, 2017 [Online]. Available: http://batteryuniversity.com/learn/article/charging_at_high_and_low_temperatures. [Accessed: 19 - Sept - 2017].