NAU NORTHERN ARIZONA UNIVERSITY
School of Informatics, Computing, and Cyber Systems

Bugs Life

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Subject: Design Doc 2

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Introduction:

For the capstone project “Smart Lamps," the needs of the client are relatively simple. The lamp is used for collecting insects so that scientists can collect data and study what the insects are doing and what they are telling them about the area and its environment. We are trying to achieve longer lasting batteries without the hassle of replacing batteries every 4 hours. Working with their previous design, they would like the lamp to function for around 30 hours, up from its current 4 hours. The lamps will be deployed on river expeditions down the Colorado River in the Grand Canyon, which last 7-27 days. The lamp needs to operate for one hour each night. Additionally, regardless of how this is achieved, the client has specified that the spectrum of light be maintained from their previous design to keep their data consistent. Lastly, for the complete prototype, all components must fit into a 40-mil ammo can. The client also stated that the minimum amount of time they are looking for from the lamp is 15 hours. For the client, around 20 hours of battery life would be the ideal amount needed for the trips, and 30 hours would be the best case scenario.

The ideal design should be easy for the user to operate because the device will be incorporated into a community science project and will be primarily deployed by commercial river guides. Community scientists receive between 10-20 minutes of training before collecting data in the field. Our design will be very simple to set up and easy to use. The design must also not overheat.

Concept:

For this project, we are creating a design that will eliminate all battery waste by implementing solar for recharging the power source. Through solar charging, we will eliminate the constant replacement of double A batteries. This project design will utilize two 6-volt lipo batteries in series in order to create 12-volts for the 12-volt power regulator. The power regulator will connect the solar panel, the battery, and the light bulb. For our final design, we are installing a digital thermometer and utilizing DC male and female connectors for easily connecting and disconnecting the solar panel and the light bulb. The threaded DC connector with the dustproof plug will help keep the parts and ammo can well sealed, and weatherproof. The outside of the ammo can has a digital temperature gauge so that you will always be able to read the temperature inside the can to make sure that nothing is overheating while either charging or in use.

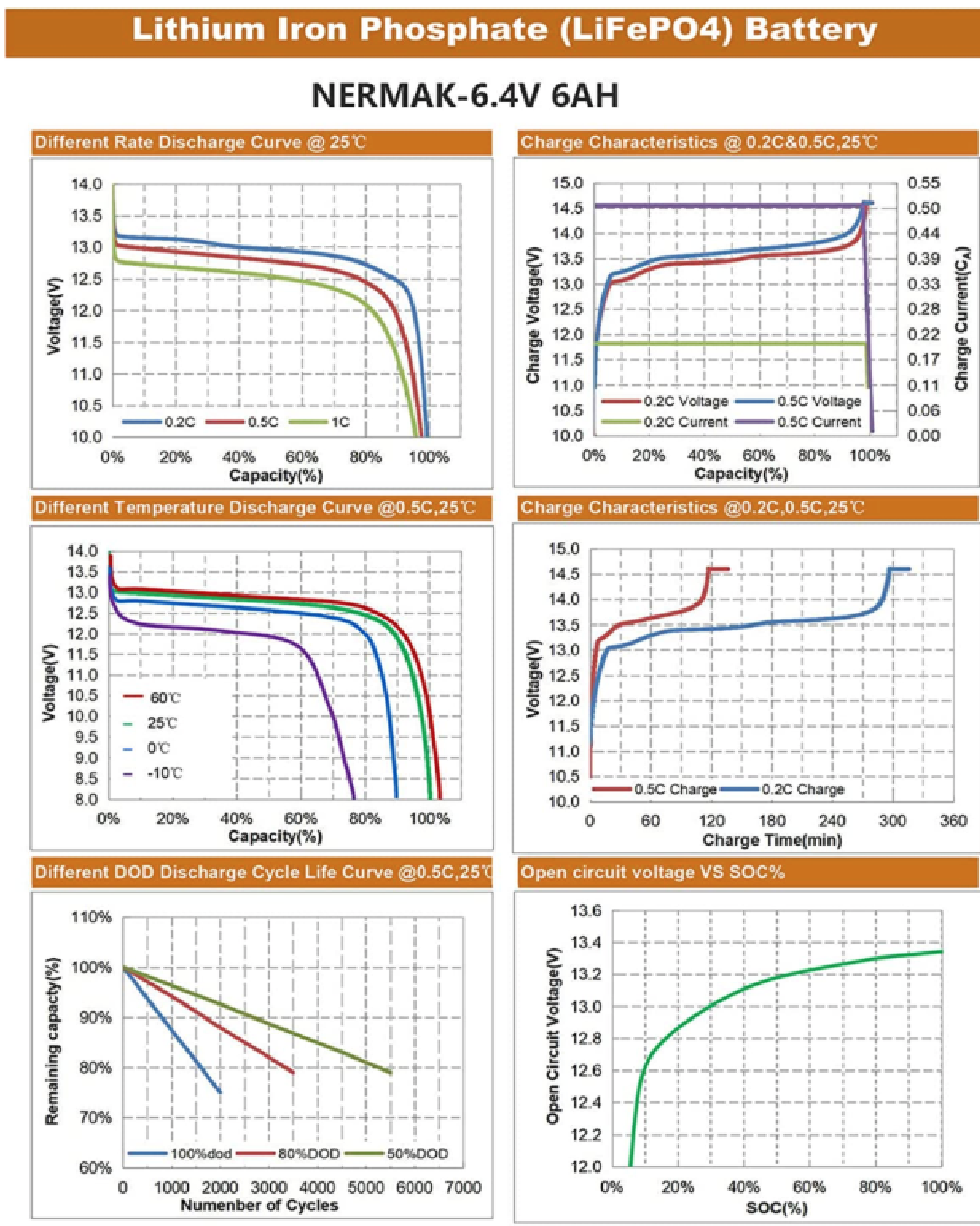
For the inside of the ammo can, we will use double-sided tape to secure all parts that will not need to be removed, and we will also use foam to secure the batteries so that they will not be able to get banged around inside the can while on these expeditions. The solar power regulator is a 12-volt charge regulator that will keep our batteries charged without overcharging them, which would cause them to go bad. This charge regulator has two USB ports with a 2.4A max for any other charging that the user would need, for instance charging a phone. This regulator also has two DC output ports installed in the device. This model of the regulator is fairly advanced and has a built-in timer and an internal temperature sensor. This model also allows us to set the voltage at which we want to charge the two 6-volt batteries that are connected in series.

Technical Approach:

The LiFePO4 batteries hold their charge perfectly for our design. While we are still in the beginning stages of running our tests and putting each part under extreme conditions to make sure that our project will not disappoint, the LiFePO4 batteries are exceeding our expectations.

Below are graphs from our LiFePO4 battery. The graphs show the different discharge rates, charge characteristics, and open circuit voltage within our batteries.

Fig.1



Construction of Ammo Can:

The project is complete with all components connected, which include the two LiFePO4 batteries wired in series, a 12V charge regulator, a digital thermometer, a solar panel, and a buck converter to the specified lamp from USGS.

On the outside of the ammo can, we have a digital thermometer that is wired to an on/off switch right next to it to easily check the temperature inside the ammo can. In between the two on/off switches, there are two female DC ports with rubber dust covers to protect from the elements. The DC port closest to the digital thermometer is for the solar panel hookup, and the DC port to the right of that is for the lamp that was given by USGS. Next to the last DC port previously discussed is the on/off switch for the batteries (which also turns on and off the charge controller). Lastly, there are two USB charging ports under the thermometer, covered by a dust cover to protect it from the elements. The USB ports will allow anyone to charge a phone, watch, or anything else that has a USB plug. Below is a picture of the ammo can with the finishing touches to the outside of the can.

Fig.2

Tests:

We started testing on Friday, March 3rd. We began by setting up the solar panel in a window seal connected to the charge regulator. This allowed us to get a complete charge on the two batteries wired to the regulator as well. The temperature of the can read 78-80 degrees while charging and did not exceed 80 degrees while direct sunlight was hitting the ammo can. After the system was charged from the brief charging through the solar panel, we started our test by running the bulb for different times on different nights without charging to see how long the light would run on a single charge to the system. Below are the dates and the actual run time of the light on those specific dates.

Friday March 3rd: Ran light for 1hr 30 min.

Monday, March 6th: Ran light for 2 hours. (took before and after pictures to see if there would be a difference in brightness).

Fig.3

9:30pm:

Fig.4

11:30pm:

The light had no change in brightness.

Tuesday, March 7th: Light ran for 2hrs. (The charge controller reads 13V still)

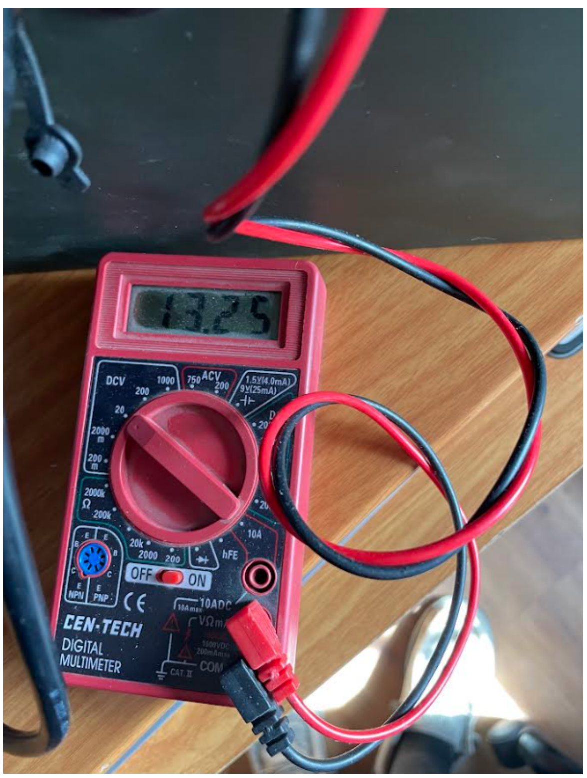
Wednesday, March 8th: Ran light for 3hrs.

Thursday, March 9th: Ran light for 4hrs 15min. (charge controller reads 12.8-12.9V)

The total time the light has run so far on just one single charge is 12 hours and 45 minutes. The charge controller still reads around 12.8-12.9V which is great and will give us plenty of charge to exceed the clients expectations. We are still testing and will get more data on the average run time, and the approximate time it will take to fully charge these two LiFePO4 batteries wired in series.

Below are pictures of the multimeter testings. The first test was done directly to the batteries connected in series. This picture in figure 5 shown below shows the batteries reading 13.25V with no load on the batteries. In figure 6 the multimeter read 13.14V with the light running.

No Load: Fig.5



Light turned on: Fig.6

The voltage drop from no load to the light turning on is 0.9V. The light is still getting bucked down to a steady 5.22V (tested with a multimeter). The bulb is rated for 6V and by bucking the 12V source to 5.22V makes for the best solution for sustaining the bulbs life expectancy and getting the most use out of a single bulb for the river guides expeditions to collect their data with our project.

Fig.7

Challenges and Difficulties:

Untitled Gantt Project Mar 8, 2023

Fig.8

Gantt Chart 3

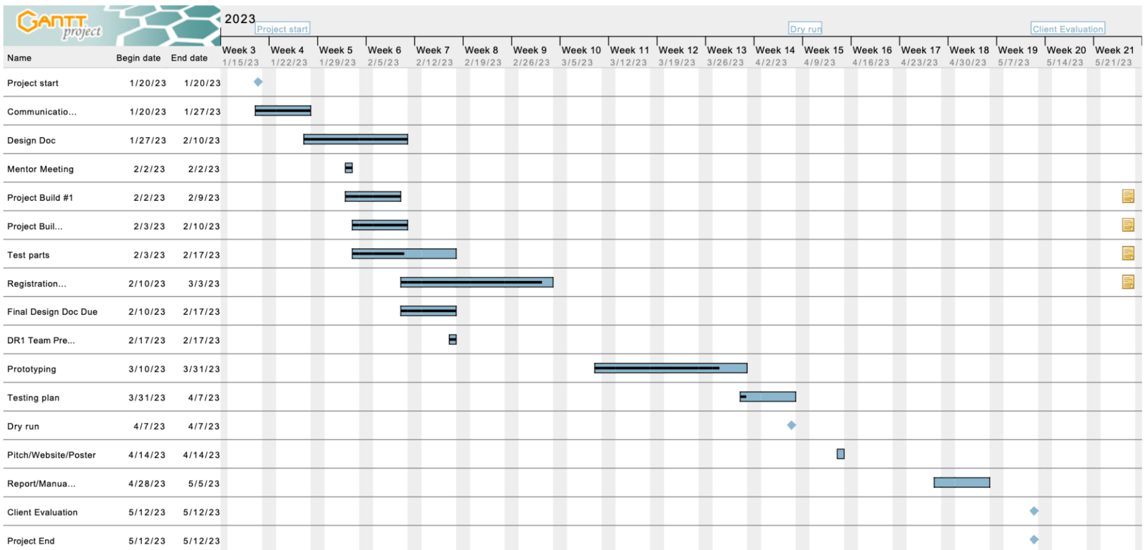


Fig.9

Untitled Gantt Project Mar 8, 2023

Tasks 2

Name	Begin date	End date
Project start	1/20/23	1/20/23
Communications Memo	1/20/23	1/27/23
Design Doc	1/27/23	2/10/23
Mentor Meeting	2/2/23	2/2/23
Project Build #1	2/2/23	2/9/23
Project Build Continued	2/3/23	2/10/23
Test parts	2/3/23	2/17/23
Registration for UGrad	2/10/23	3/3/23
Final Design Doc Due	2/10/23	2/17/23
DR1 Team Presentation	2/17/23	2/17/23
Prototyping	3/10/23	3/31/23
Testing plan	3/31/23	4/7/23
Dry run	4/7/23	4/7/23
Pitch/Website/Poster	4/14/23	4/14/23
Report/Manual/Reflection	4/28/23	5/5/23
Client Evaluation	5/12/23	5/12/23
Project End	5/12/23	5/12/23

For this section, we are going to talk about our team's challenges and difficulties with our project. Above is our Gantt chart that shows all our progress this semester and where we are currently at. We will go deeper into the Gantt chart later in this section.

Our team's challenges, we really did not have many challenges with our project. However, we did have some minor challenges. One of our smaller challenges is fitting every part of our design into the ammo can we were provided. Our clients provided us with an ammo can that is 17 cm long. The main issue we are having is that the size of our MPPT charge controller is taking up most of the length of our ammo can. We are able to fit all our components into the ammo can, but it is a tight fit. Our team is worried that with all the components close to each other, the ammo can will heat up much faster than expected. We have tested the temperature under maximum load, and we are not seeing any dangerous temperatures while in testing. This is why it is not a major issue; the box is just a little cramped. In our box, we are thinking about adding a timer in our circuit to control our light so it will only run for an hour before turning off. If we want to put the timer in, we will need to change some parts to be smaller so the timer can be fixed. This is a problem because we already have a working product with the parts we have. We will need to decide if we want to downsize the MPPT charge controller to fix the timer in the ammo can.

Recently, we had a meeting with our clients and talked about the length of time they wanted the battery to last. Previously, they wanted the battery life to be 30 days. In our meeting, we decided on 15 hours for the new battery life. They decided this would be more reachable for our project's goal. Our clients only go out for 15-day trips with the bug-trapping device, so 15 hours is all that is necessary for them.

Our team has decided to buy the smaller charge controller and timer to replace our bigger charge controller. With the smaller MPPT charge controller, we will be able to fit the timer comfortably in the ammo can with no issues. This should fix our cramped ammo can problem as well as add the timer to the design. Having the timer in the design will help greatly with our battery life. With the timer set to run for an hour when turned on, the light will only be on for 1 hour each day and no longer, which will help our battery life last the full 15 days.

On our Gantt chart, we have a few newly completed tasks. As you can see above, we have finished prototyping. We have a fully functional design built to fit inside our ammo can. We added external plugins for the lamp, solar panel, and USB plug. Each of these ports was sealed tightly so the elements could not get in. We needed to accomplish this task so that we could be on time for testing our product. We have already begun some of our tests, the main one we are running at the moment is battery life under full load. Our team is simultaneously looking at the temperature when the device is running to make sure the temperatures in the ammunition can never exceed a dangerous level, which for our design is around 135 degrees Fahrenheit. We are currently just at the beginning of our testing task on our Gantt chart. We have many more tests to run before we can check off the testing portion, which is why we needed the prototype to be done on time. This allowed us to run all our tests and be done in the time frame we set!

Plan for the Second Half of the Semester:

When it comes to testing the functionality of our lamps, there are several key areas that need to be assessed. These include battery life, light intensity, temperature, and charge times. Each of these factors can impact the overall performance of a lamp, and it is essential to ensure that each is functioning correctly.

Battery life is a crucial component of our smart lamp. It is important to determine how long the lamp can be used on a single charge and how quickly the battery drains. Testing the battery life can be done by using the lamp for an extended period and monitoring how long it lasts before the battery runs out. This data can then be used to estimate how long the lamp can be used before needing a recharge. This will also ensure that we meet our clients requirement of 15 hours in minimum run time.

Light intensity is another critical factor in the functionality of our lamps. The intensity of the light emitted by the lamp can affect the lamp's usefulness in collecting data for their outdoor activities. Testing light intensity involves measuring the number of lumens that the lamp produces, which can be done using specialized equipment. This data can then be used to determine how bright the lamp is and how long the light can remain at that intensity before dimming.

Temperature is another important factor in lamp functionality, as overheating can pose a risk of damaging the electrical components in the can. Testing the temperature involves monitoring the lamp's temperature during use and determining whether it stays within safe limits. This is accomplished using a thermometer gauge within the system.

Finally, testing the charge times of a lamp is important to ensure that it is convenient to use. Charge times can be tested by fully charging the lamp and monitoring how long it takes to reach a full charge. This data can then be used to estimate how long it takes to charge the lamp and whether it is convenient for our client. If their expedition exceeds the 15 hour minimum, it would be useful to know how long the batteries can be fully charged again.

In the context of our smart lamp project, one crucial aspect is the selection of an appropriate MPPT (Maximum Power Point Tracking) controller. MPPT controllers are used to optimize the power output from solar panels, ensuring that the lamp receives a consistent and efficient supply of energy.

To make the smart lamp project even more functional, we will need to select a smaller MPPT controller that can incorporate a programmable timer. The programmable timer will enable us to tailor the lamp's operation to meet the specific needs of our client. For instance, we can set the timer to turn on the lamp to automatically shut off after one hour of the required run time, ensuring that the lamp is operational during the night and conserving power during the day.

By selecting a smaller MPPT controller with a programmable timer, we can improve the lamp's overall efficiency and make it more convenient for the user. The programmable timer will enable the user to set the lamp's operation according to their specific requirements, thereby enhancing the lamp's functionality.

The selection of an appropriate MPPT controller and the incorporation of a programmable timer require careful consideration of several factors. These include the power output of the solar panel, the lamp's power requirements, the expected operating time of the lamp, and the environmental conditions of the installation site. With the right selection and configuration of the MPPT controller, we can ensure that the smart lamp project is a success, providing reliable and efficient lighting to our client.