Portable Solar Panel for Military Use

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INTRODUCTION

Background

Battlefield digitization, the process of upgrading military communication and information, is considered to be the most valuable advantage in warfare. The protection and use of information is achieved through this research and application of technology. Soldiers today heavily rely on the use of electronics in order to successfully complete their missions. With an endless amount of scenarios that could cause battery failure, a solar powered failsafe device would guarantee recharge of their equipment. In today's modern warfare, if a soldier runs out of power, their mission is terminated. The client for this project is Dr. Loren Sumner who is an associate professor of mechanical engineering at Mercer University's School of Engineering. The team consists of Logan Bradford, Michael Quinn, and Will McCarthy. Logan and Michael are majoring in mechanical engineering, while Will is specializing in environmental engineering.

Deliverable

The ultimate goal of this project is to capture solar energy and store it in a single rechargeable battery so that, given the worst-case scenario, soldiers are able to charge their electronic equipment in the field. This prototype will be a failsafe device for soldiers in the field who are stranded or just in need of power to charge their necessary electronics such as radios, night vision, and targeting devices. The device should be lightweight and be able to withstand a variety of conditions. The project deliverable will be a prototype composed of a solar panel, battery, and housing.

METHODS

The recommended final design consists of an exterior tubular shell made of lightweight PVC. This shell will be 4.0 inches in diameter and 18 inches tall. This will allow adequate room to allow for the solar panel, which is 3 inches in diameter and 14.6 inches in height when rolled up, and the battery with wiring to fit. The battery used will be a rechargeable 5600 mAh12V lithium-ion battery that is 2.5 inches in diameter and 3 inches tall. This will easily fit in the shell well also having adequate mAh capacity for captured energy. The tube will be sealed on one end with a threaded cap on the other end for easy deployment. The flexible solar panel will be rolled up and inserted into the capped end when stored. The battery that will hold the captured energy will be located inside the shell secured to the sealed end. Coming out of the battery will be the wires to the solar panel with a zener diode in between to avoid losing energy out of the panel as well as the wires to charge the military electronic devices. These charge wires will be run out of the side of the shell through a small sealed hole to allow for easy recharge of equipment. Below in Figure 1, the wiring diagram of the device is shown.

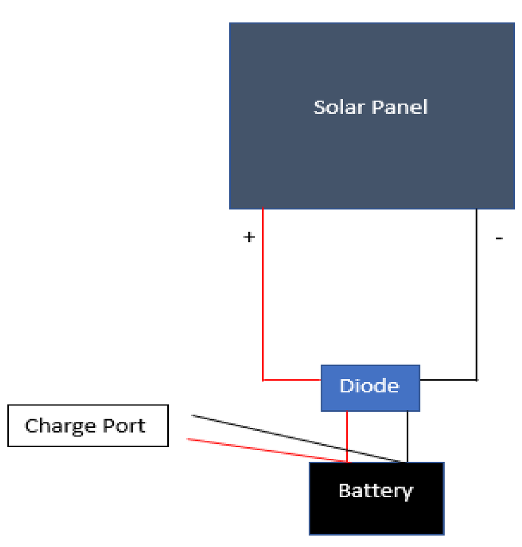

Figure 1: Final Design Wiring

Due to circumstances that were out of our control, we were unable to complete as much testing as we would have liked to for the portable solar panel prototype. The main test is the Performance Test.

<u>Performance Test</u>

The purpose of this test was to determine the amount of volts, watts, watt hours, milliamp hours, and current that the solar panel was able to produce. This was measured using a DC multifunctional battery monitor meter shown in Figure 2. The testing includes three, 4-hour sessions during different weather conditions. The first 4-hour test was completed during an overcast and rainy day, while the second was done during a partly sunny day. The final 4-hour test was done during ideal conditions; a very sunny day. This was done in order to find out how much energy could be harnessed during the ideal sunny day as well as a suboptimal day when the sun is behind clouds. The 4-hour duration was chosen because during a mission, soldiers will very rarely be in one place for an extended period of time, especially not a full day. The results for all three tests are shown in the results section.

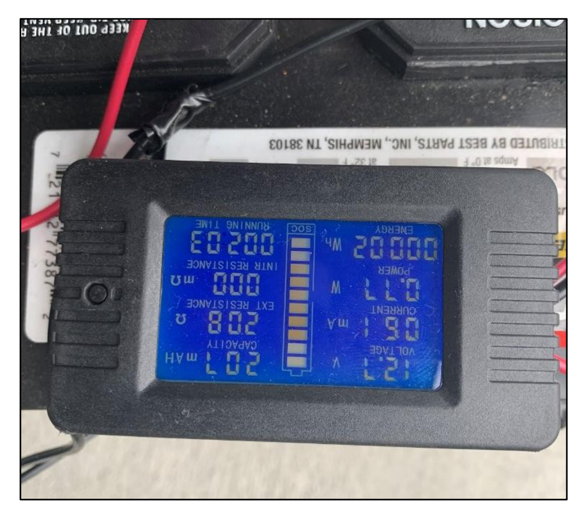

Figure 2: DC Multifunction Battery Monitor Meter

RESULTS

Performance Test Results

Overcast test results are shown below in Table 1, partly sunny results are shown in Table 2, and sunny results are shown in Table 3. As expected, a sunny day allows the solar panel to produce the most energy.

Table 1: Overcast Test Results

Performance Values	Results
Average Voltage	12.7 V
Peak Voltage	12.8 V
Average Current	60 mA
Peak Current	100 mA
Average Power	0.89 W
Peak Power	1.4 W
Total wH Captured	3 Wh
Total mAh captured	310 mAh

Table 2: Partly Sunny Results

Performance Values	Results
Average Voltage	12.8 V
Peak Voltage	13.0 V
Average Current	515 mA
Peak Current	826 mA
Average Power	4.1 W
Peak Power	10.9 W
Total Wh Captured	18.0 Wh
Total mAh captured	1400 mAh

Table 3: Sunny Results

Performance Values	Results
Average Voltage	13.1 V
Peak Voltage	13.3 V
Average Current	650 mA
Peak Current	900 mA
Average Power	9.2 W
Peak Power	11.3 W
Total Wh Captured	35.0
Total mAh captured	2710 mAh

Testing Set Up

Shown in Figure 3 is the set up for the performance test. The testing area was moved from an open field to a balcony due to circumstances out of the team's control. Each performance test for varying weather conditions took place on this set up to keep the testing controlled. The solar panel was adjusted every 30 minutes to optimally face the sun. This device was then wired to a 12V car battery. This battery would not be the battery used in the prototype, due to its size and weight, but was ideal for testing due to its capacity. The group also encountered problems with the first battery of the prototype, which made the 12V car battery switch necessary.

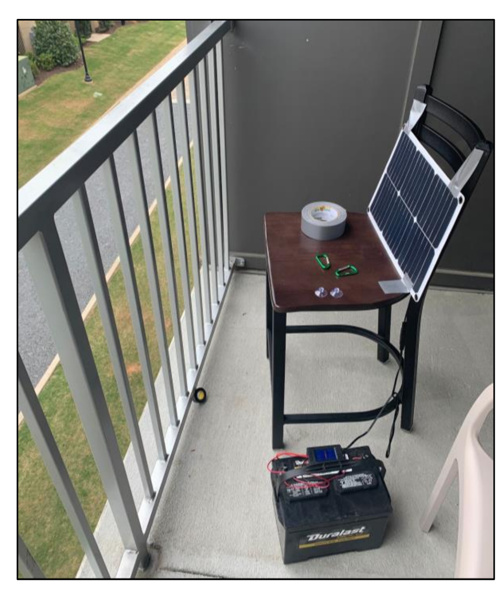

Figure 3: Testing Setup on Overcast Day

CONCLUSIONS

Test Conclusions

The first two hours of the overcast test were done during desired overcast conditions, but the latter two hours the weather worsened, and it began to rain. Though energy was still being captured, the rain conditions reduced the power and current the panel was capturing to almost a quarter of what it was getting in the overcast conditions. This change reduced the total energy captured, but it allowed the team to observe what could be collected in not only suboptimal, but almost worst-case conditions. The positive is that, the solar panel still collects energy in the worst-case scenario. During the partly sunny test, the total watt hours collected was 6 times higher than the overcast test and the total milliamp hours collected was about 4.5 times more. For the sunny test, the values were the highest of all 3 tests with voltage peaking at 13.3 V, power at 11.3W, current at 900 mA, Wh captured at 35.0 Wh, and mAh captured at 2710 mAh.

Were Prototype Goals Met?

The typical military radio is the Motorola SRX 2200 which has a battery capacity of 3100 mAh. Though the overcast day fell way short of this mark, if it was extrapolated to a full day of charging, about 8 hours, it could have captured around 600 mAh. Though this would not fully charge a radio, it would give the soldier enough to make a few calls to get help. On the partly sunny day, the panel captured 1400 mAh over 4 hours, meaning with a full 8 hours, around 2500-2800 mAh could be captured. This would be nearly enough to fully charge a radio and allow the soldier to continue with their mission. Finally, with the ideal sunny conditions, the panel captured 2710 mAh in 4 hours, which would be well over 5000 mAh in an 8-hour window. This would be enough to fully charge a radio for a soldier with energy left over to charge other devices or save the energy if on an extended mission. Overall, the amount of energy the prototype was able to capture met our goals.

Design Recommendation for Future Innovation

Unfortunately, due to the nationwide dealings of COVID-19, other tests that the team expected to complete were unable to be attempted. The team believes that this type of device will eventually become necessary for soldiers in the field. Future research should be focused on developing solar panels that are flexible enough to fold or roll into a variety of shapes and sizes. This will allow for many versatile designs to be developed and tested. Instead of just a failsafe device, the main goal should be to replace the need for soldiers to carry any other batteries in the field besides the device itself. Different external protective solutions should also be researched to find the best option for protecting the solar panel while allowing it to unfold and roll properly depending on the design while maintaining a lightweight. A reliable device that can constantly be recharged when necessary will be an important asset to soldiers as technological advancements of electronic equipment become more critically important in the battlefield.

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