Experiment A7
Solar Panels II
Procedure

Deliverables: checked lab notebook, full technical report (due the week after fall break)

Overview

This week, you will conduct an independent experiment using the solar panels and other related equipment. By now, you should have enough competence to design and conduct an experiment on your own. You have free rein to measure whatever you like, so long as it is related to the solar panels. We encourage you to go outside and perform field tests (weather permitting). There are a number of different solar panels and light filters you may use. You may also use any piece of equipment from the previous labs, within reason.

For your lab report, you will be required to make a schematic of your experimental set-up and a plot of the data you measured. You will also be required to perform a brief, independent case study of your choosing, where you quantitatively analyze the practicality of solar energy for various applications.

Laboratory Equipment

- There are several different solar panels for you to choose from, including the small 5W panels from week A and larger 20W panels that are either "polycrystalline" or "monocrystalline".

Caution: Do **NOT** use the 20W solar panel with the normal load box. It will burn out the resistors! We have a special load box with power resistors for you to use with the 20W panels.

- There are optical filters to test the solar panel response to different colors of light.
- There are various lab stands you may use to mount the solar panels and equipment.
- You may also use the irradiance sensors, handheld DMMs, and any other portable electronic equipment from the lab.
- Ask for a box to carry your equipment, if you plan to go outside.

Experimental Setup

The instructions from Week A are repeated here for convenience.

1. Set the toggle switch to "Short" or "Closed"(load toggle in Figure 1).
2. Plug the red banana cable on the solar panel into the red receptacle A on the load box.
3. Plug the black banana cable on the solar panel into the black receptacle B on the load box. (Refer to Figure 1 for further clarification.)
4. Connect the leads of the solar panel into "*Input A*" on the load box (input 1 in Figure 1).
5. Connect the "*V*" leads of the load box (V_{meas} in Figure 1) to the Keysight Precision DMM using the BNC coaxial cable with banana plug adapters on the end.
6. To measure the current, use the orange handheld DMM set to the 200mA range, and connect it to the "*I*" leads on the load box (I_{meas} in Figure 1) using the banana plug cables.
7. Locate the **Irradiance Sensor** (dark blue box). It has twelve different settings that can be chosen for sensitivity and scaling of the voltage output. Setting (9) is recommended for this laboratory exercise.
8. Connect the Irradiance Sensor leads to the "Sensor Interface Box": The black wire should be on the top pin (GND), then red on the +5V pin, and yellow on the "SIG." pin. Ignore the loose green wire. (The sensor interface boxes have a pin-out diagram on the bottom left corner.)
9. The sensor interface box should display a voltage that will increase linearly with irradiance. Professor Patrick Dunn has created a document that explains how to determine the irradiance in $\mu W/cm^2$ from the voltage output of the sensor. This document can be found on the lab website along with the handout and score sheet.

Location Notes

In your lab notebook, make detailed notes, such as: location, light source, temperature, etc., which may affect the outcome of your experiment and include it in your report/discussion.

Case Study

Perform a *quantitative* analysis of the practicality of solar energy (i.e. perform actual engineering calculations). Think of various applications where solar power could be used as an energy source (i.e. powering a cell phone, a laptop, a washing machine, and air conditioner, or an electric vehicle). Look up how much power these various devices require. Would solar energy be feasible? How many batteries would you need to run the various devices and appliances? How many panels would you need to charge these batteries in a single day?

Lastly, look up the average irradiance of the sun in northern Indiana and compare it to other locations around the world. How does northern Indiana compare?

Overall, this analysis must be quantitative in nature. A bland discussion of energy policy will be awarded no points!

Week II Deliverables – Download the LaTeX or MS Word template from the course website and use it to write a brief lab report, no longer than 8 pages. You are required to include the following items in your lab report **along with the items from the previous week**. (See the score sheet for points.)

1. Using whatever software you prefer (besides MS Paint), make an original schematic illustrating your independent experiment.

2. A plot and/or table of data of the results you obtained in your experiment.

3. A *quantitative* analysis of the solar panels' usefulness for various different applications. Your analysis should include a table summarizing the important numbers from your analysis.

Suggested Talking Points – This lab is to test your ability to work *independently*, so these are merely *suggestions*. Feel free to be as creative as possible in your analysis.

- Look up how much power is used by various items such as a cell phone, a lap top, an LED lamp, and incandescent lamp, an air conditioner, and electric heater, an electric vehicle, a washing machine, a clothes dryer, etc. Quantitatively analyze how many solar panels would be needed.

- Look up the efficiency of other solar panels. How do the ones you tested compare?

- Analyze the monetary cost of implementing a solar panel array. Be sure to include the cost of the batteries for energy storage at night and available tax credits. How long would it take to recoup the initial cost of building the solar array?

- Look up the specs for the 12V battery. Based on the current you measured in your field tests, how long would it take to charge the 12V lead acid battery?

- Solar panels do not work at night, so it is necessary to store some of the energy produced during the day. Do some research on existing battery technology. For example, a large portion of Tesla's business model is to sell their Lithium ion batteries for just this purpose.

- Look up the solar irradiance in various parts of the world. How do your locations compare?

- Look up the total energy consumption for the United States and the World. How many of these solar panels you need to meet these energy demands?

- If you are truly a dreamer and have faith in unbound progress, do a Google search of "Dyson Spheres" and see how deep the rabbit hole goes!