

Experiment A7 Solar Panels II Procedure

Deliverables: checked lab notebook, **Full Lab Report** (due the week after break)

Overview

This week, you will conduct an independent experiment involving the solar panels and the properties of light. 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. Overall, the results from your independent experiment should show some clear trend.

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.

Part I – Independent Experiment

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 last week 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 $\mu\text{W}/\text{cm}^2$ 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.

Part II – Independent Case Study

In your lab report, please present a *quantitative* analysis of the practicality of solar energy. You must perform actual engineering calculations. **A bland, qualitative discussion of energy policy will be awarded zero points.** The case study does NOT need to be related to your independent experiment. Possible topics to discuss and analyze are listed below.

- 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 and how much they would cost.
- 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 solar irradiance in various parts of the world. How do various locations compare?
- 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. How big of a battery would you need to power a typical home? How many solar panels would you need to fully charge the battery in 12 hours?
- Look up the average power consumption for the United States and the World. How many solar panels (total area) would you need to meet these energy demands? What would be a good location to build such an array? How much would it cost to build a solar energy array big enough to power the entire US or world? How does this compare to the annual GDP and federal budget? How does the cost compare to some of the “green energy” proposals touted by politicians? (Be sure to include citations and be **quantitative** in your comparisons.)
- If you are truly a dreamer and have faith in unbound progress, do a Google search of “Dyson Sphere” and prepare to conquer the galaxy! How much would it cost to build such a device? How much energy would it produce? What could the energy be used for?

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. (Keep in mind, the reader likely does not know what you did for your experiment, and the purpose of this schematic is to clearly explain it to them.)
2. A plot and/or table of the results you obtained in your independent experiment. The plot or table should *simplify* the data for the reader and illustrate an important take-away. (A massive “data dump” with no clear take-away will be awarded zero points.)
3. A *quantitative* analysis of solar panels’ usefulness for various applications.
 - a. Your analysis should include a table summarizing the important numbers from your analysis.
 - b. The case study does NOT need to be related to your independent experiment.
 - c. Do NOT use an online “app” to do calculations for you.

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.

- The results from your independent experiment should show some clear trend in the data. What is the big take-away from the experiment?
- Do some online research. Has anyone performed an experiment similar to yours? How do your results compare to theirs?

Appendix A

Extra Equipment Available for Independent Experiment

- Lab stand w/ 3-finger beaker clamp
- Large 25 W solar panel
- Extra Small 0.1 W solar panel
- Angle mount
- Protractor
- Level
- Tape measure
- Colored light filters
- Mirrors
- Fresnel lens
- Water
- Ice (please email us in advance)
- Sand