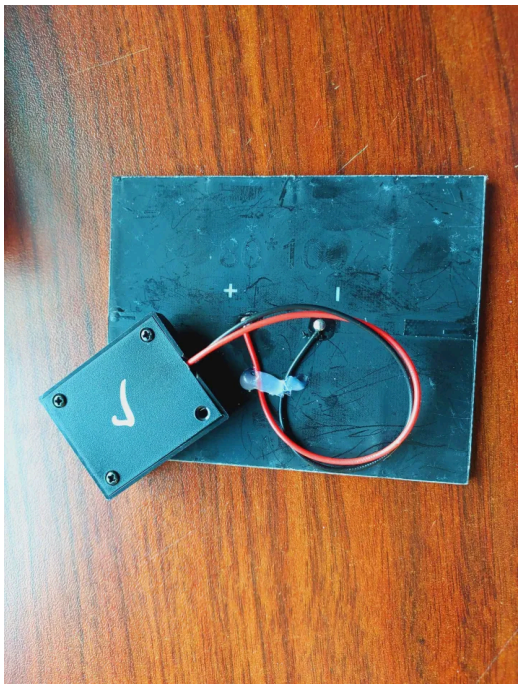
Power presentation

1. **How to charge the battery with the solar panel**

- To charge the battery with the solar panel, start by using a solar panel with a voltage slightly higher than the battery's, such as a 6V or 5.5V panel for a 5V battery.
    - important as for current to flow into the battery, the voltage from the panel needs to overcome the battery's voltage.
        - current flows from higher potential to lower potential, so the solar panel’s voltage must be sufficiently greater than the battery's to initiate charging.
- Next, the solar panel is soldered to a USB adapter board, such as the SparkFun USB Adapter.
    - This adapter typically provides a regulated output (like 5V) suitable for charging your USB-powered battery.
- Add a diode (**an electrical component that allows current to flow in only one direction (forward direction) and blocks it from flowing in the opposite direction (reverse direction).**) on the VCC (+) (**the positive voltage line, where the solar panel is providing power.**) line between the panel and the adapter



    - to prevent the battery from discharging back into the solar panel when sunlight is not available.
    - The diode ensures that the current flows only from the solar panel to the battery, preventing any reverse current flow into the panel.
- Once everything is connected, plug the battery into the USB adapter board.
- When the solar panel is exposed to sunlight, it will start charging the battery by supplying current to it.
    - will allow CubeSat to charge the battery efficiently using solar power.

2. **How to power the Raspberry Pi, IMU, and camera**

- Use a rechargeable USB power bank that can power the Raspberry Pi, IMU, and camera. Make sure it fits in the 10x10x10 cm CubeSat frame.
- The power bank should be able to supply enough power for all the components, but the battery size (mAh) doesn't matter much for this project
- If you want to use a solar panel to charge the power bank:
    - Pick a 6V or 5.5V solar panel to work with a 5V power bank

- Solder the solar panel to a Sparkfun USB adapter board
- Add a diode to the VCC (+) line to stop the battery from sending power back to the panel
- For the IMU (inertial measurement unit):
    - Choose one that has 9 degrees of freedom (3 axes each for accelerometer, gyroscope, and magnetometer)
    - Adafruit IMUs are a good choice, and they work with CircuitPython libraries
- For the camera:
    - Use either the Visible or NOIR Raspberry Pi camera, but you only need one.
        - Both cameras connect the same way but detect different types of light
    - Make sure everything, including the battery and wires, fits inside the CubeSat

3. **How and why to use the USB power meter**

- How to Use:
    - The USB power meter measures both voltage and current through a USB connection
    - Insert the meter between your power bank and the device you want to monitor (Raspberry Pi, IMU, Camera)
    - The meter will give you real-time information about the power draw of the device(s) being powered
        - useful for tracking whether your CubeSAT system is operating within your available power budget
- Why Use:
    - **Power Monitoring**
        - Keeping track of the power consumption for each device ensures you don't overload the system or drain the battery too quickly
            - important in satellite operations where power availability is constrained
    - **Efficiency Optimization**

        - If the meter shows high current draw or unexpected spikes, you may need to adjust the power distribution (e.g., by using more efficient converters or optimizing power usage patterns).
    - **Troubleshooting**
        - If one of your components isn't working as expected, the power meter will help identify whether it's a power-related issue (e.g., insufficient voltage or current).

4. **Change the clock speed of the Raspberry Pi (why would you do this?)**

- The Raspberry Pi's performance is tied to its clock speed, but increasing the clock speed also increases the power consumption.
    - Lowering the clock speed can reduce power draw, which is important if your CubeSat mission is power-limited.
    - Adjusting the clock speed is a trade-off between performance and power efficiency.
- How to Adjust the Clock Speed?
    - You can change the Raspberry Pi's clock speed by modifying its CPU governor settings.
    - The default setting is usually "ondemand", which adjusts the clock speed dynamically based on system load.
    - You can change this to "powersave" to minimize power consumption or "performance" to maximize processing power.

5. **Power Draw of All Components**

- Power Draw is the the amount of electrical energy used to operate a device over a period of time
- Measuring Power Draw:

    - Use the USB power meter to measure the current and voltage draw of each component (Raspberry Pi, IMU, and camera). The power consumption is given by the formula $P = V \times I$.
        - Raspberry Pi: The Pi may consume around 2-3W depending on its peripherals.
        - IMU: Typically consumes very little power (in the mW range).
        - Camera: Camera power consumption can vary but is usually around 0.5W to 1W.
    - Total power draw can be calculated by adding up the power consumption of all components.

6. **Determine how long it takes to fully drain and fully charge the battery. Can you plot the battery voltage and current over time?**

- Battery Discharge Time:
    - Monitor the battery voltage over time using the USB power meter
    - The battery will typically start at around 4.2V when fully charged and drop to 3.0V or lower when discharged
    - Measure the time it takes for the battery to discharge under typical load (Raspberry Pi running with the IMU and camera connected).
- Battery Charge Time:
    - Need to fully charge the battery with the solar panel and track the charging time
        - The solar panel will typically charge the power bank fully in several hours of direct sunlight, depending on the solar panel size and light conditions
- Plotting the battery's voltage and current over time will provide insight into the efficiency of the charging and discharging cycles

7. **Determine the incident angle of light on the solar panels – how can you adjust this?**

- an incident angle is the angle formed between a ray of light hitting a surface and a line perpendicular to that surface at the point of contact
- Why Adjust the Incident Angle?
    - The solar panel will generate maximum power when the sunlight strikes it perpendicularly (90°).
    - By adjusting the angle of the solar panel to face the Sun directly, you can maximize the energy harvested
        - critical when the CubeSat is in orbit
- How can you adjust this?
    - can manually adjust the solar panel or use a sun-tracking system if CubeSat has one
    - The goal is to maintain an optimal angle as much as possible during the mission