Proof of Concepts Milestone 1

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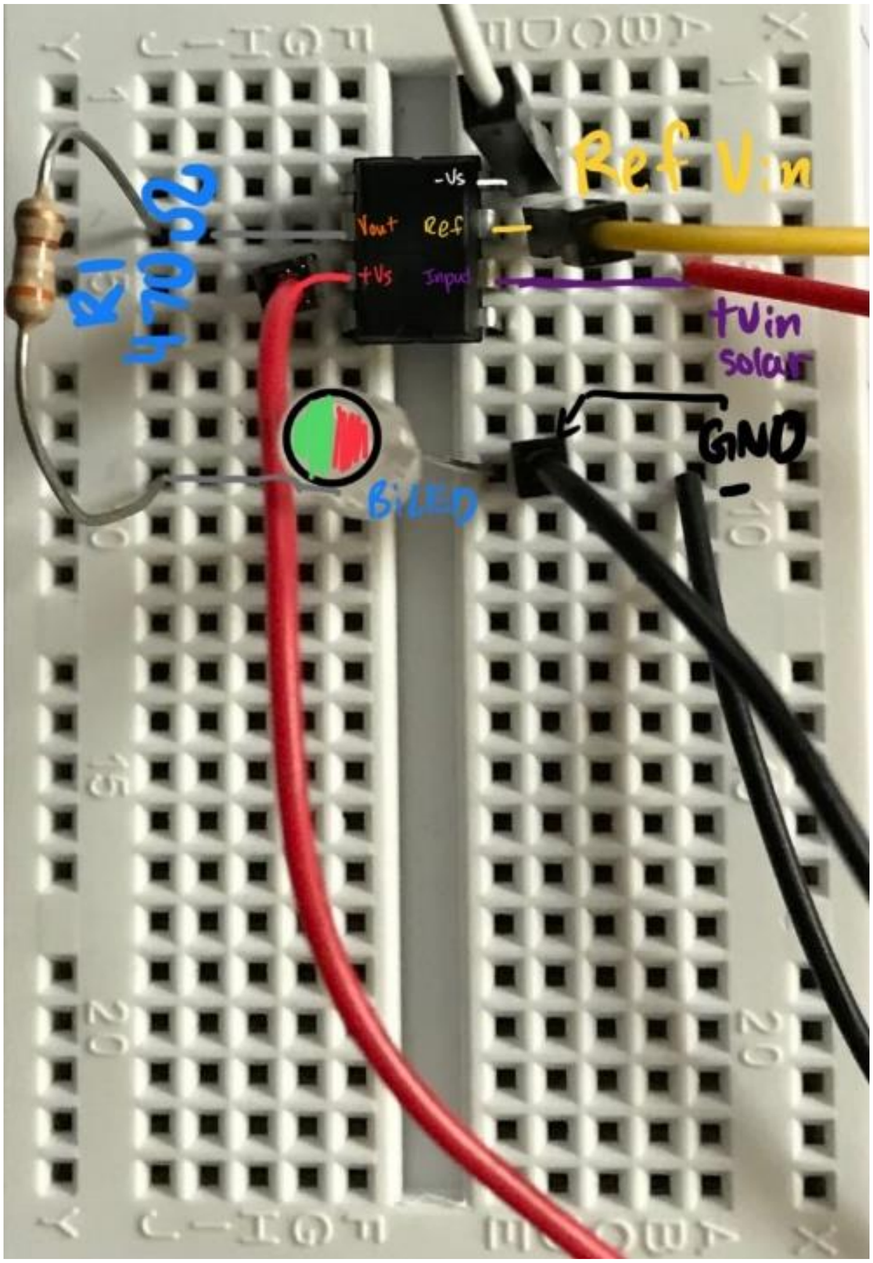
Labeled Circuit Diagram



Solar Panel Specification:

- **Output From Single Panel:**
  - **5 volts**
  - **3 milliamps**
- **Output From array:**
  - **5 volts**
  - **9 milliamps**

Concept 1: KCL/Ohm's Law

Description

Kirchhoff's current law applies when we are feeding in a DC source supplied by the v-supply of the op amp to our bi-led. When we get enough voltage from the solar source, the Bi-led will turn green. Otherwise, the bi-led will be red. When the bi-led is green, it indicates that we have enough power to switch directly from our dc source to our solar source.

The resistor that we used has a 5% tolerance so it can be +/- 23.5 Ohms. This makes the resistor with a range of **446.5-493.5 Ohms**. So, the current's magnitude can be in a range of **0.0101-0.0112 A**.

This also does not account for the internal resistance of the wires, and BiLED. Therefore, the **current will be a little bit less** than what we calculated here.

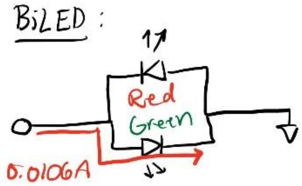
Analysis

$V_1 > V_2$ (Solar Power > Non-renewable):

$V_{out} = +5V$

$$I_{R_1} = I_B = \frac{V_{out}}{R_1} = \frac{5V}{470\Omega} = 0.0106A$$

BiLED:



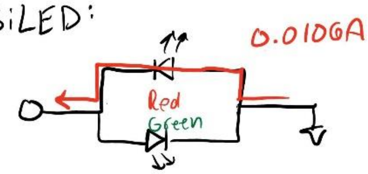
Green LED turns on

$V_2 > V_1$ (Non-renewable < solar power):

$V_{out} = -5V$

$$I_{R_1} = I_B = \frac{V_{out}}{R_1} = \frac{-5V}{470\Omega} = -0.0106A$$

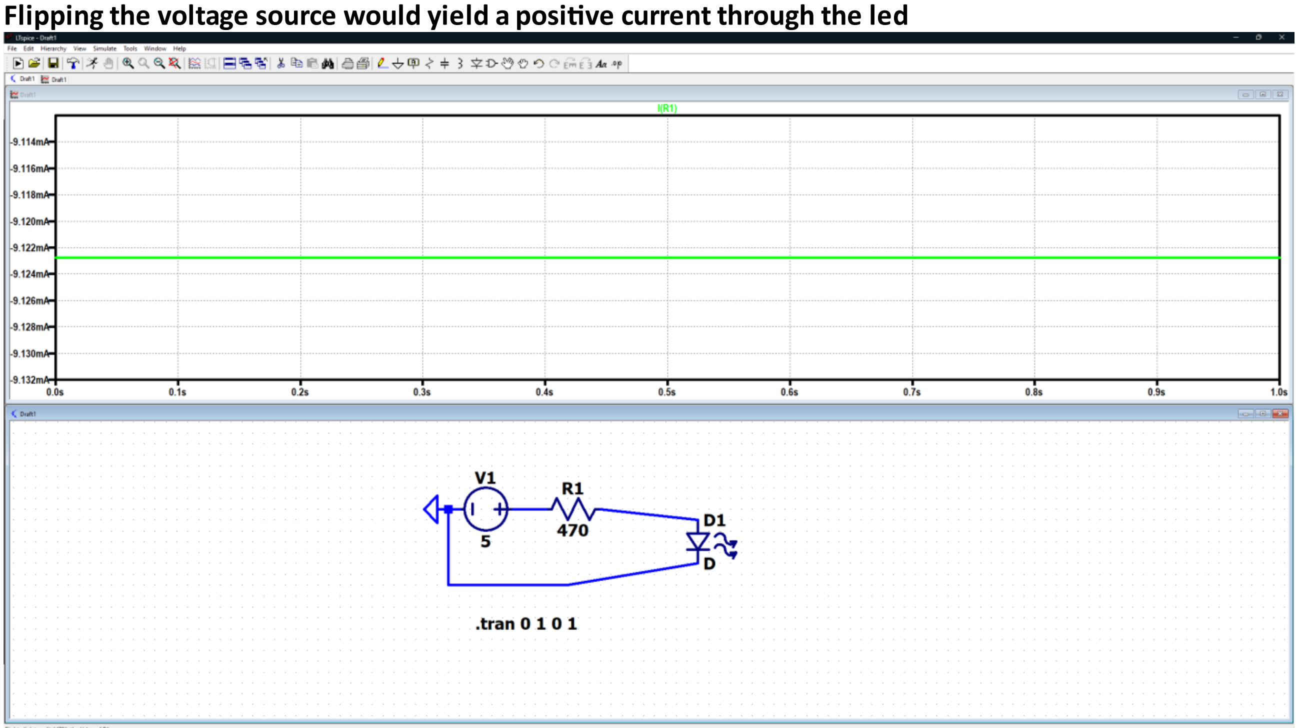
BiLED:



Red LED turns on

LT SPICE SIMULAON

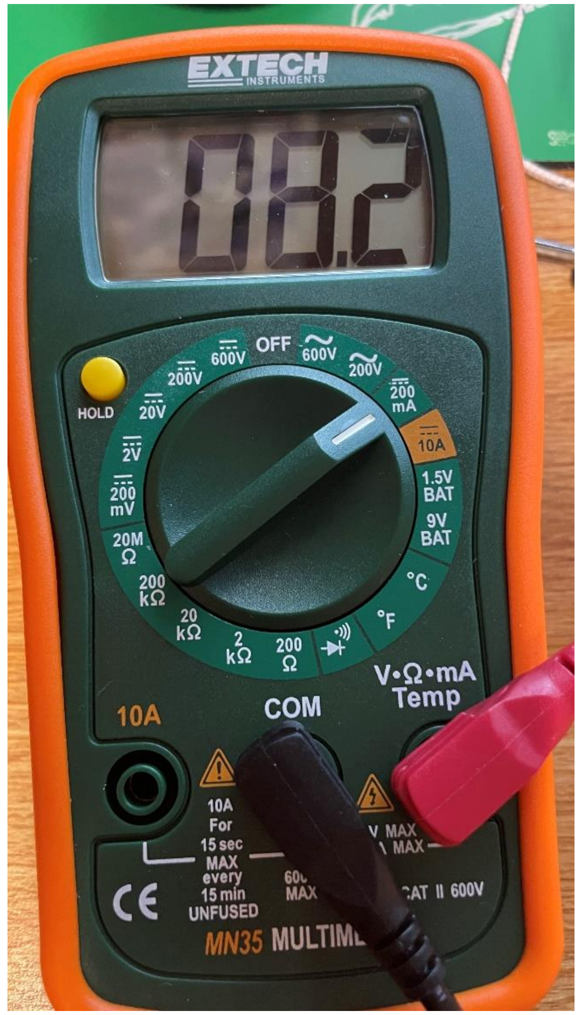
Flipping the voltage source would yield a positive current through the led



Experimental Data

Current measured from -5 volt output from op amp

Current Measured from +5volt output from op amp



Results

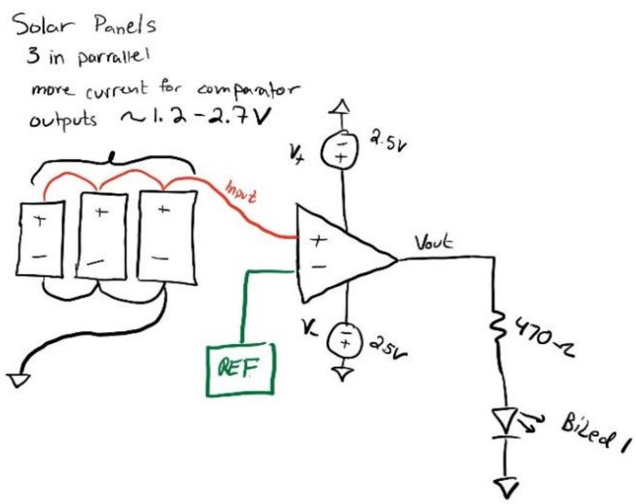
+/- 8.2 mA is the current through the BiLED in the physical circuit. This coincides with what we got in our mathematical analysis of the circuit where we got a range for the current of 0.0101-0.0112 A (+/- 10.1-11.2 mA). Though 8.2 is not in the range of 10.1-11.2 this makes perfect sense because in our calculation we do not account for internal resistance of the wire, or BiLED. The greater resistance value would make the current drop since I=V/R (Current and resistance are inversely proportional).

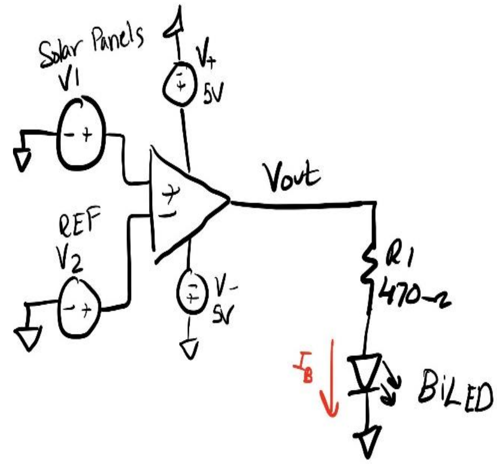
Concept 2: Operational Amplifier as a Comparator

Description

We built a comparator using a reference voltage coming from the m2k (models Non-Renewable Energy Source) and measured the voltage coming from our solar panel (models Renewable Energy Source).

Analysis





If V2 > V1 (Non-renewable is greater):

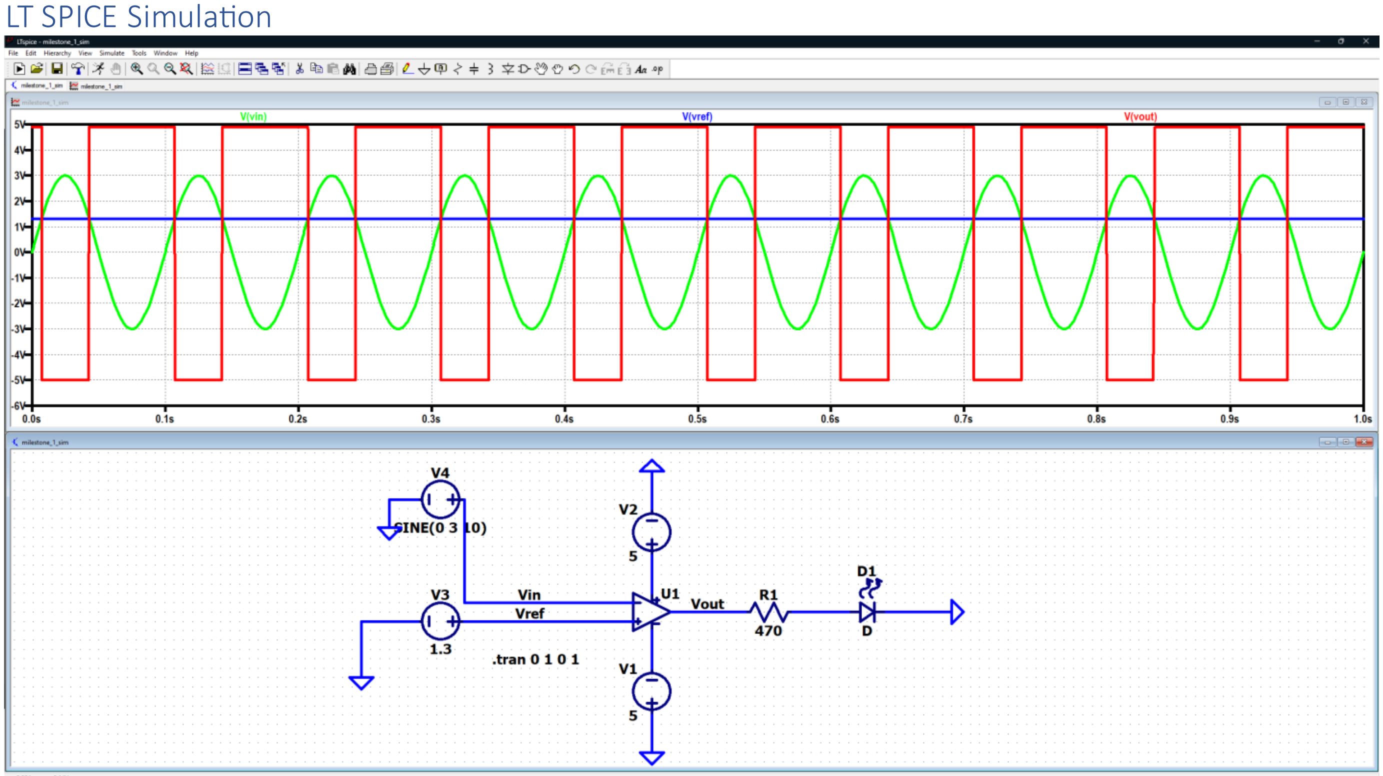
- IB will be negative (Current through BiLED)
  - Negative current means BiLED will light red

If V1 > V2 (Solar Power is greater):

- IB will be positive (Current through BiLED)
  - Positive current means BiLED will light green

V supply voltages can be changed based on the total voltage required. For our purposes we are using +/-5V for the V supply voltages.

LT SPICE Simulation

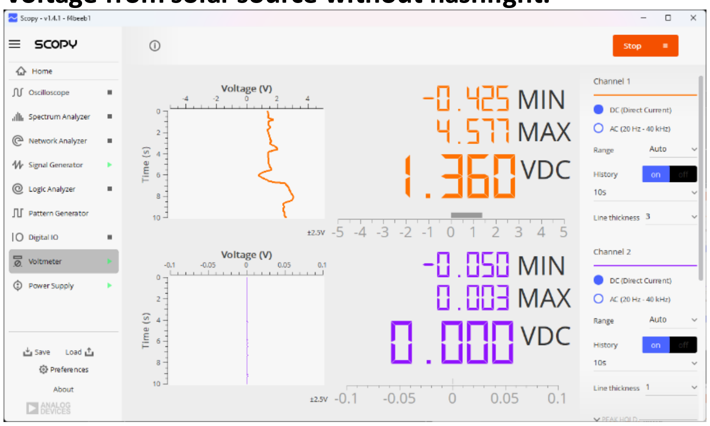


Experimental Data

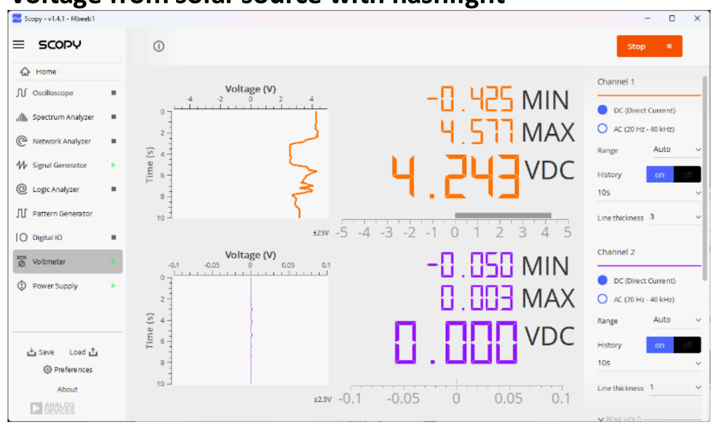
Voltage output from op amp without enough voltage from solar source.

Voltage output from op amp when voltage from solar source has reach desired level.

Voltage from solar source without flashlight.



Voltage from solar source with flashlight



Results

In our mathematical analysis we determined that using the op amp with a vref and a vin we should either get an output of positive 5 volts or negative five volts. With our designed circuit we can adjust the sensitivity of the required reference voltage to better match the varying voltages from the solar panel. While we assumed that the solar panel would output between 1.2 - 2.7 volts, our actual experimentation proved otherwise. We saw that in our experimental measurements from ambient room lighting we got .614 V from the flashlight and with the flashlight shined at the solar panel, we would get around 1V.

Behavior-wise we saw the op-amp perform the intended function in our circuit. We used a Reference voltage of 3V to model the energy from a Non-Renewable energy source and whenever the solar panel was able to produce a voltage higher than 3V, we would swap our power sources from the negative power source to the positive power source.

Conclusions and Results:

Benefits of analysis:

It lets us mathematically determine the expected results of our prototype and if the circuit is theoretically feasible.

Difficulties:

The difficulties we encountered while completing this milestone were mostly making the comparator. While trying to make the op-amp comparator we ran into voltage and current problems. One solar panel was not outputting enough stable current and voltage that the op-amp needed to be able to measure it. We ended up connecting three panels in parallel to output more stable voltage and current.

Learned skills and concepts:

How to apply a comparator of amp to measure a varying voltage source to determine if it has reached desired power levels. We also determined what resistor to use to output a valid current and voltage for our indicator bi-led.