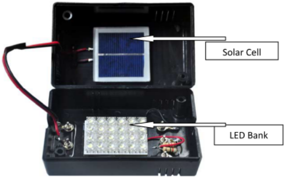
I/V Characteristics of Solar Cell

Electronic Devices Lab : Experiment 4

Department of Electrical Engineering
Indian Institute of Technology, Bombay
June 21, 2022.

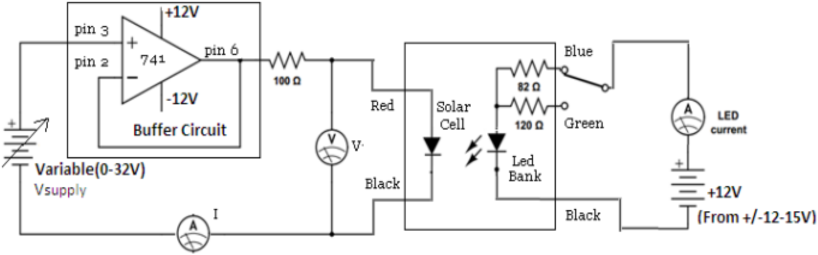
Think it. Make it. Prove it.

- The experimental set-up for this experiment uses a “black box” shown in figure comprises of a solar cell and an LED bank consisting of 24 white LEDs



Think it. Make it. Prove it.

Part 1: Measurement of I-V characteristics



- Connect the circuit as shown in figure. The description of the buffer circuit with IC pin configuration is given at the end.
- Make sure that the solar cell box is covered and no voltage is applied to the LED bank.

Part 1 a): Dark I-V characteristics

This part of the experiment measures the I-V characteristics in forward and reverse bias of the solar cell in the dark.

- Set voltage range of DMM to 20V and current range to 20mA. Take all the readings with these settings.
- With the variable power supply vary V_{supply} and note down current and voltage through the solar cell under "Dark" condition as I_D and V_D respectively.(Please note the polarity of I_D and V_D while taking readings)
- Note that you will have to change the input polarity of V_{supply} of solar cell arrangement manually while changing from –ve bias to +ve bias voltage.

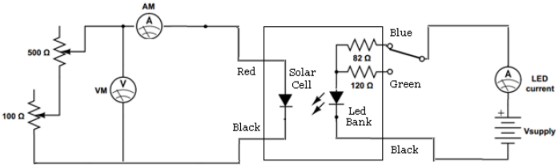
Part 1 b): I-V characteristics under light

In this part of the experiment, you will measure the current-voltage characteristics for two different levels of illumination I_1 and I_2.

- The level of illumination is changed by changing the current through the LED bank by connecting appropriate series resistance.
  In this part of the experiment, take many readings in the fourth quadrant (positive voltage and negative current).
- Connect the LED bank to power supply and select the 120Ω resistor by connecting the wire to the "Green" terminal marked for intensity I_1.
- Note down the current through the LED bank. Vary V_{supply} from $-2V$ to $2V$ (for WEL-4 students) and note down current and voltage through the solar cell under "lighted" condition as I and V respectively.
- Follow the same steps by connecting the power supply to the "Blue" terminal marked for intensity I_2 (82Ω) of the LED bank for another set of I and V readings.

Students in WEL-2 : Vary V_{supply} form $-2V$ to $+5V$.

Think it. Make it. Prove it.

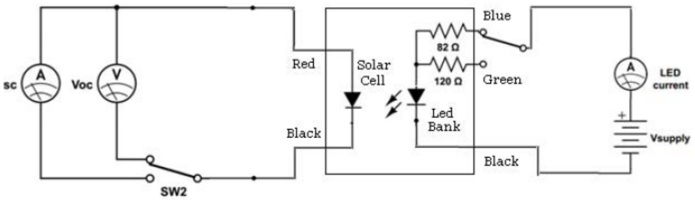


- Connect the circuit shown in figure. You can now use the 0-32V variable supply for LED bank.
- Shine light on the solar cell for I_1 by connecting "Green" terminal of LED bank and setting V_{supply} to 12V.
  Note the LED current (It should be equal to I_1 currents in Part 1).
- Measure I_L and V_L by varying potentiometers. Use 100 ohm pot for fine and 500 ohm pot for coarse variation. Take the readings till the current I_L falls to almost zero.
- Repeat the steps for I_2 by connecting "Blue" terminal.
  Note the LED current (It should be equal to I_2 currents in Part 1).

Since the characteristic curve is nonlinear, take more readings in the "knee" region of the curve.

Think it. Make it. Prove it.

Part 3 : Measurement of V_{OC} and I_{SC} at different illumination levels



- Connect the LED bank to the variable power supply (0-32V) by connecting V_{supply} to "Blue" terminal via DMM (for measuring I_{LED}) and another DMM to across the solar cell as shown in figure. Connect a DMM across the cell such that just by swapping to voltage and current ranges you can record both V_{OC} and I_{SC} for a given value of I_{LED}. Note that there is no switch SW2 but you will manually swap the settings.
- Set $I_{LED} = 10\ mA$ by adjusting V_{supply} and measure V_{OC} and I_{SC}.
- Repeat the above steps for I_{LED} $10\ mA$ to $50\ mA$ in steps of $10\ mA$ by varying V_{supply}.

Think it. Make it. Prove it.

Report

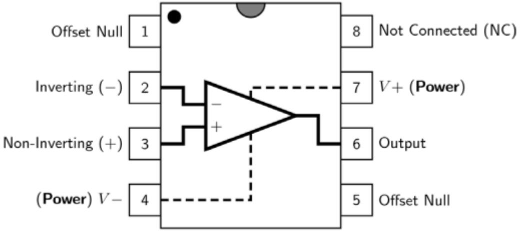
- Plot the I-V characteristic of the solar cell that you measured from part 1 for dark, and from part 2 for intensity I_1 and I_2.
- From the data from part 2, plot I as a function of V. From this graph find I_{sc} and V_{oc} for two intensities I_1 and I_2.
- Using the data collected in part 2, plot power P as a function of V on the same plot obtained above. Determine the voltage V_{MP} at which the power P reaches maximum. Find the current I_{MP} at the same point. Using I_{MP} and V_{MP}, calculate the fill factor.

$$FF = \frac{I_{MP} \times V_{MP}}{I_{sc} \times V_{oc}}$$

- Superimpose the readings of part 1 obtained in the fourth quadrant and readings obtained in part 2. Do they match?
- Plot I_{sc} v/s light intensity (I_{LED}) and V_{oc} v/s $\log(I_{LED})$. This experiment shows that I_{sc} varies linearly with light intensity and V_{oc} varies linearly with log of intensity.

Think it. Make it. Prove it.

IC 741: Operational amplifier



- In the circuit arrangement of part 1 the operational amplifier IC741 is used as a voltage buffer. The buffer is a single-input device which has a gain of 1, mirroring the input at the output. The current through solar cell is required to sink in the fourth quadrant. The push-pull arrangement in the output stage of the opamp provides "sink path" to the reverse current in the solar cell.

Think it. Make it. Prove it.