Temperature Dependence of Solar Cell Characteristics

Wadhwani Electronics Lab

Department of Electrical Engineering
Indian Institute of Technology Bombay
August 2014

The Problem Statement

So far we have characterized semiconductor devices at room temperature. It will be interesting to see how their parameters vary with temperature. The device under test for this experiment is a solar cell.

In this experiment we will

* plot dark forward I-V characteristics at different temperatures.
* plot lighted I-V characteristics at these temperatures.
* observe the effect of temperature on cut-in voltage, V_{oc}, I_{sc}, fill factor and ideality factor.

Prelab Work

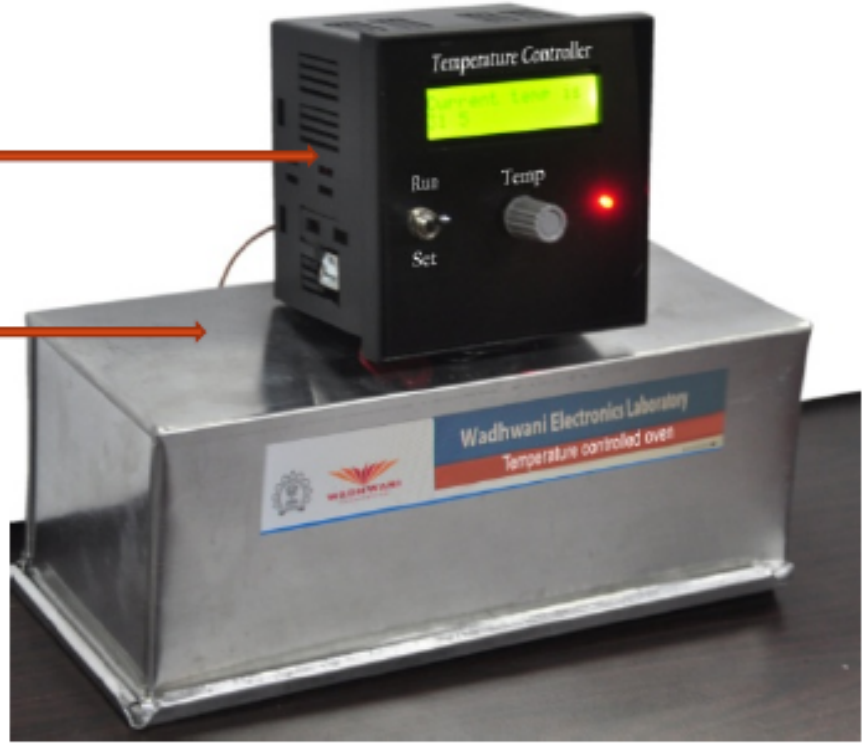
* Please revisit the labsheet on Solar cell I-V characteristics.

* Make sure that you have read the supporting material uploaded along with this document.

About the Experimental Set-up - 1

Temperature Indicator and Controller

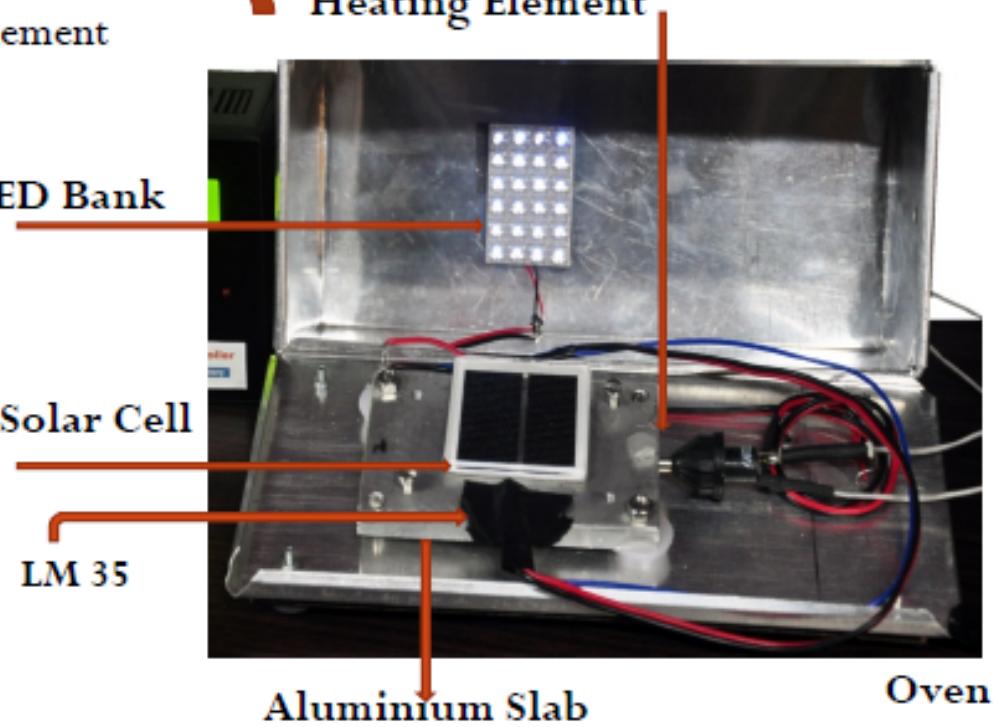
Temperature Controlled Oven



About the Experimental Set-up - 2

Aluminium Slab is heated by the heating element which in turn heats up the solar cell at the temperature set by the controller.

Temperature Controller



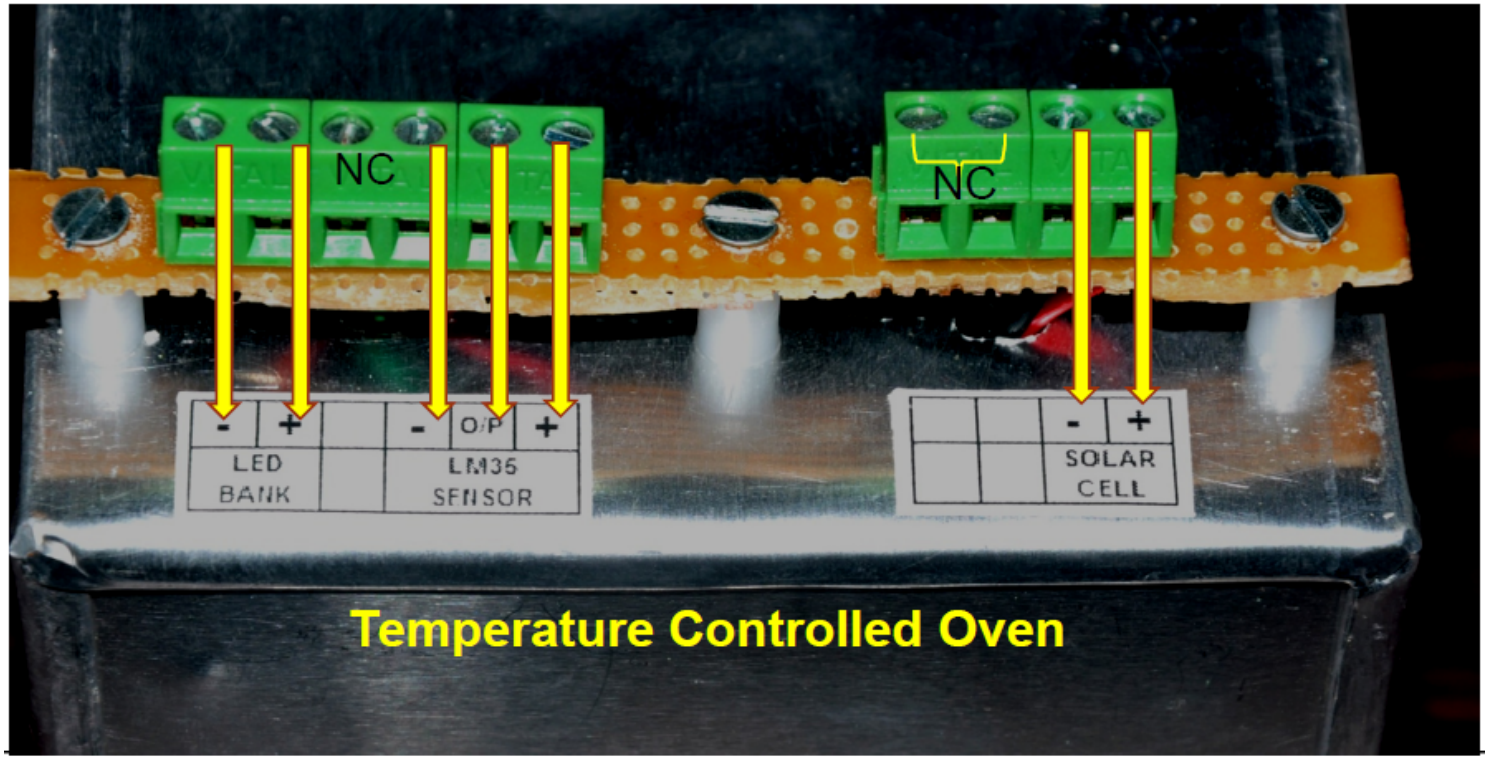
Desired temperature is set by putting the **RUN/SET** switch in **SET** mode and by controlling **Temp** knob.

The heater then starts heating once the switch is put in **RUN** mode.

This is a simple ON-OFF controller with +/- 2 ^{o}C hysteresis.

About the Experimental Set-up - 3

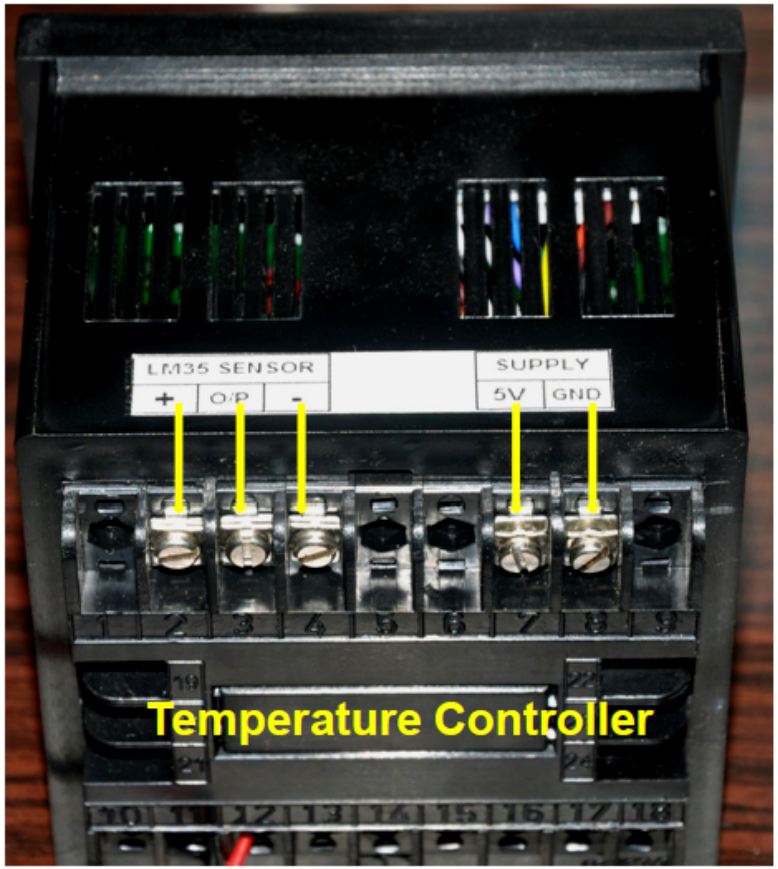
* LED Bank should be connected to 12 V DC with the polarity shown.
* LM35 (the temperature sensor) connections to those of the temperature controller connections are shown in next slide.
* Solar cell connections will be made using the breadboard.



About the Experimental Set-up - 4

* LM35 connections from the oven.

* 5 V supply for the controller.



Before You Start...

* Make the connections of the binding post terminals (screws) of temperature controller and oven. Connect the heating element to 230 V mains. **HIGH VOLTAGE WARNING : BE CAREFUL WHILE CONNECTING TO THE MAINS.**

* The experiment has two parts (explained in the following slides) in which you vary the temperature from 35°C to 75°C in steps of 10°C and measure I-V.

* **Make sure that SET/RUN switch is in SET position everytime you power ON the controller. (If the switch is in RUN position before power ON, the SET register may take any garbage value and heater may remain continuously ON!).**

* Set the desired temperature by controlling the 'Temp' knob. If the set temperature is more than the current temperature, the heater will turn ON and is indicated by the LED on the front panel of the controller. In RUN mode you will see current temperature being displayed while the heater is getting heated.

Before You Start...

* The oven takes some time to attain a given temperature and even longer to cool down.

* Hence it is advised that the connections for both the parts be made on the breadboard except the solar cell connections.

* Start the experiment for Part-1 first at 35°C by connecting the cell and then Part-2 for a given temperature by taking out the solar cell connection of Part-1 circuit and connecting for Part-2. Follow the steps for Part-1 and Part-2 given in next two slides.

Part 1 : Dark forward characteristics at different temperatures

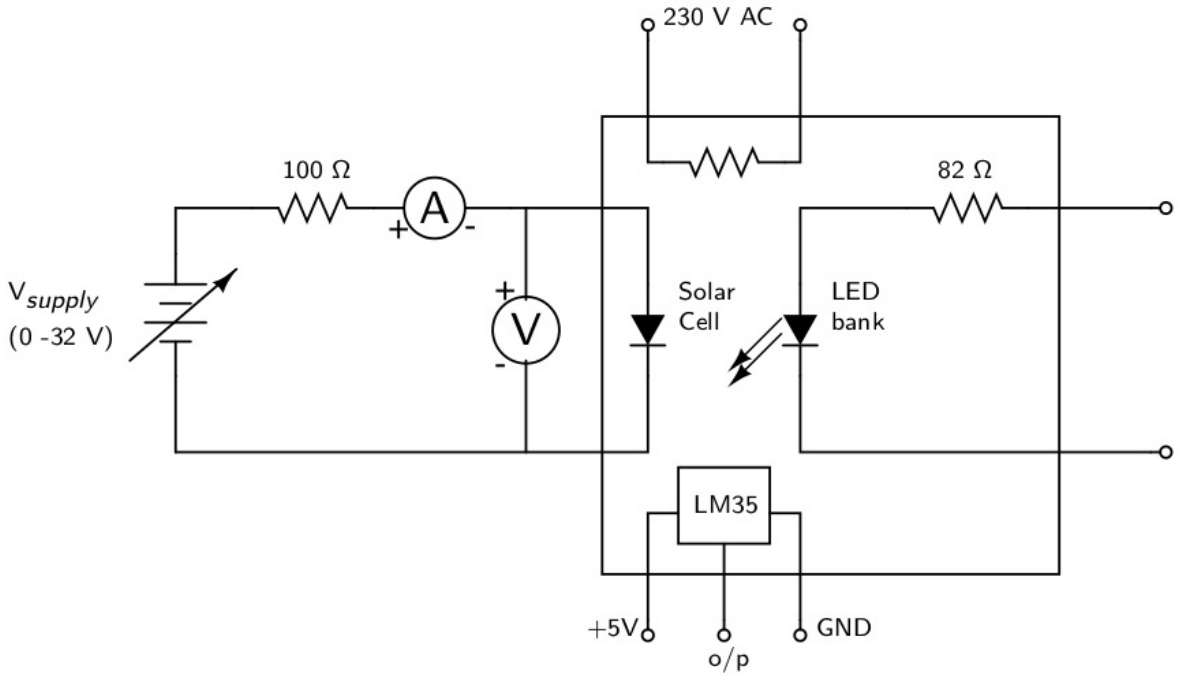


Figure : Circuit diagram for dark I/V characteristics

* In this part of the experiment, we forward bias the solar cell by applying variable voltage (from 0 V - 2 V) under dark conditions (LED bank left unconnected).Here we do not need OPAMP buffer circuit that was used in the last experiment (why?).
* Set DMMs for 2 V range and 20 mA range for V_d and I_d measurements respectively. Do not change the range throughout the experiment.
* Measure dark forward characteristics at 35°C, 45°C, 55°C, 65°C and 75°C.

Part 2 : Lighted I/V at different temperatures

* In this part of the experiment we measure I-V of the solar cell under lighted condition at temperatures 35°C to 75°C in steps of 10°C.
* Set 12 V from +/-15 V power supply for LED bank. Make sure that it is held constant.
* Measure I_L and V_L by varying potentiometers. Use 100 Ω pot for fine and 500 Ω pot for coarse variation. Take the readings till the current I_L falls to almost zero.
* **Measure V_{oc} and I_{sc} by actually open circuiting and short circuiting the device in each case.**

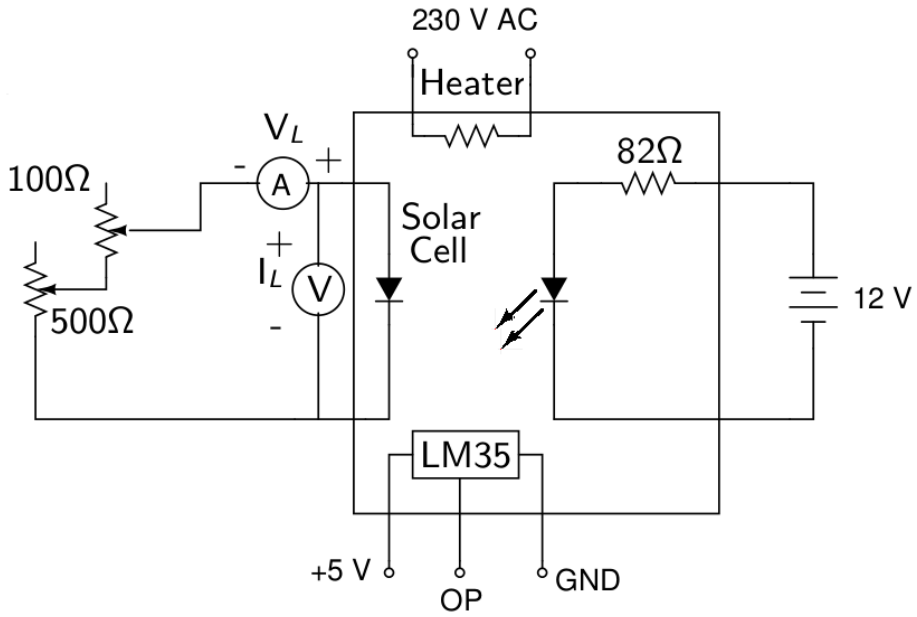


Figure : Circuit diagram for lighted I/V characteristics

Sample Plots

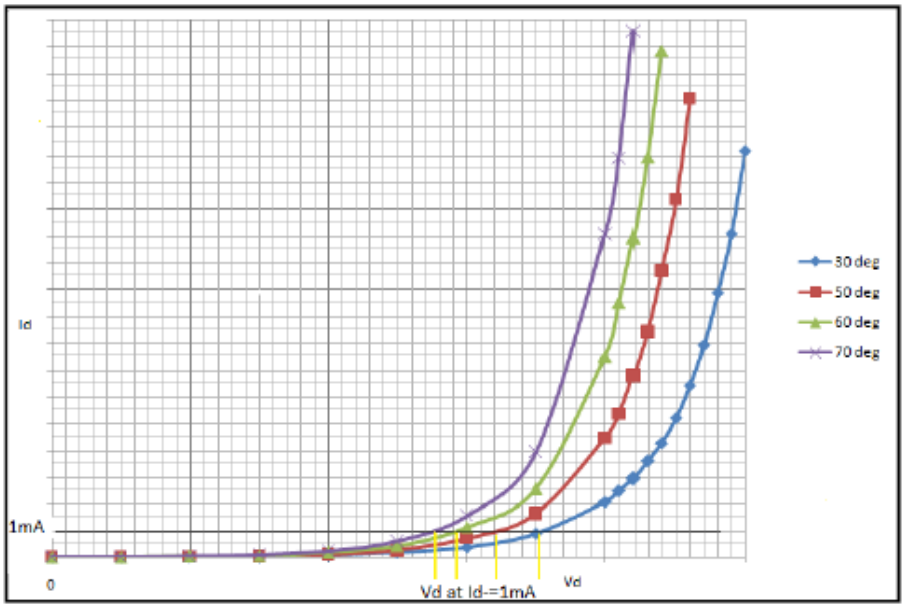


Figure : Dark forward I/V

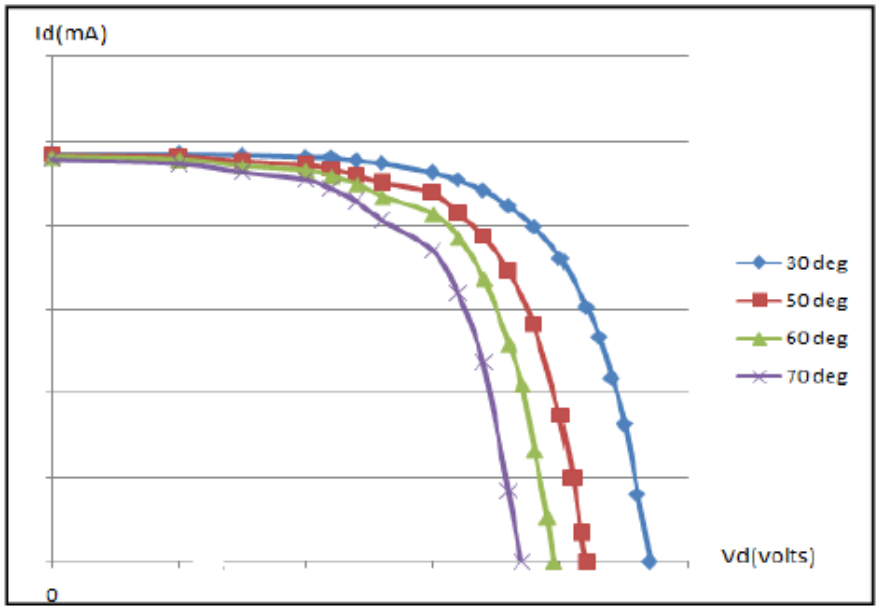


Figure : Lighted I/V

Part 1

* Plot I_d-V_d and *ln* I_d / V_d characteristics at all temperatures.
* From I_d-V_d plots find voltage at 1 mA, 2 mA and 5 mA at each temperature.
* From *ln* I_d-V_d plots, obtain ideality factor at all temperatures.

Observation Table

Temperature	V_d for I_d=1mA	V_d for I_d=2mA	V_d for I_d=5mA	η for low forward bias	η for high forward bias
35°C					
45°C					
55°C					
65°C					
75°C					

Part 2

* Plot I_L-V_L and P_L-V_L characteristics under lighted condition at all temperatures mentioned in slide 10.

* Obtain fill factor(FF) for all temperatures and plot FF v/s temperature.

* Plot V_d v/s T(temp) and V_{oc} v/s T(temp).

* Note: You will get three sets of V_d for I_d equal to 1mA, 2mA and 5mA each obtained in part - 1.

Results

Comment upon the temperature dependence of :

V_{oc}, I_{sc}, fill factor, and V_d.