# Lab 3:I-V and C-V Characteristics of Solar Cell

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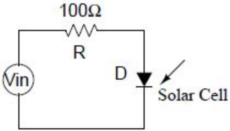
# Aim of the Experiment

- Measure the I-V characteristics of solar cell under different illumination levels and find fill factor
- Measure the C-V characteristics of solar cell and estimate the doping Concentration and built-in potential of the solar cell

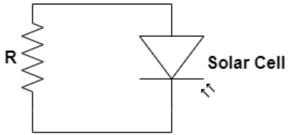
# Part 1: I-V characteristics of Solar cell

- write the ngspice netlist to plot I-V characteristics for the solar cell and find ideality factor $\eta$ for following conditions with input voltage varied from -2V to 2V (use the below circuit).




A) Dark (IL=0)
B) Lighted characteristics for the intensities corresponding to light generated current IL= 8mA and 10mA.
Hint:-For simulating different levels of illumination, you need to understand model file of solar cell provided and use the below command
X1 node1 node2 solar_cell IL_val = 10e-3 (for example simulating light generated current of IL=10mA)

# Part 2 : Measurement of $V_{OC}$ and $I_{SC}$ at different illumination levels




- In this part, we will plot the I/V characteristics of the solar cell when used as a power source. We will measure I/V characteristics when the solar cell is lighted at the intensity to generate IL=8mA,10mA
- A load resistor R is connected across the solar cell. The value of R is varied from 1 to 500Ω and the values of $I_R$ and $V_R$ are recorded (take as many values as possible to get the plot smoother)
- Plot $I_D$-$V_D$ and $P_R$-$V_D$ characteristics under lighted condition and note the values of Voc and Isc values($P_R$=$V_R$*$I_R$)

# Part 3: Fillfactor of solar cell

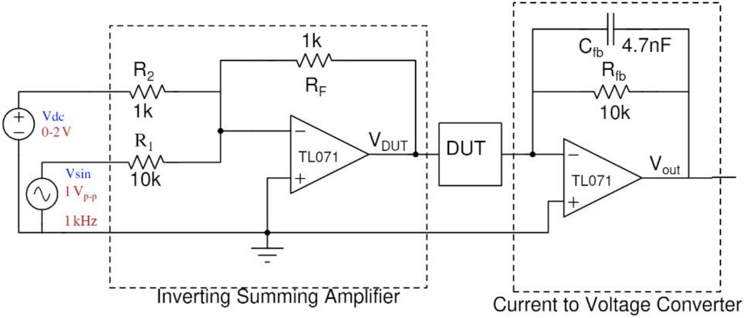
- Find fillfactor by determining the voltage $V_{MP}$ at which the power P reaches maximum. Find the current $I_{MP}$ at the maximum power point. Using $I_{MP}$ and $V_{MP}$, calculate the fill factor FF $= I_{MP} * V_{MP} / (I_{sc} * V_{oc})$

# Part 4: C-V characteristics of a Solar Cell

- When reversed biased, a PN junction exhibits capacitance called junction capacitance($C_j$). The value of capacitance depends upon the applied reverse bias voltage.
- In this part of the experiment, we intend to measure this capacitance, its voltage dependence and estimate doping profile of a PN junction.
- The PN junction under consideration is that of a solar cell.
- This can be achieved by applying a reverse bias to the diode so that it acts as a capacitor.
- To estimate the capacitance value, a small AC signal is superimposed on this DC reverse bias using a summing amplifier, and the AC current through the capacitor is measured.

# Solar Cell C-V Measurement

- The experimental setup uses the same circuit as you have used in quiz-1.
- Solar Cell is kept under no illumination(IL=0mA).
- Negative DC component of VDUT ensures -ve voltage at the anode of the cell and with cathode held at ground potential,the cell gets reverse biased.
- you have to measure the capacitance of the solar cell, $C_{DUT}$ (where DUT is solar cell here )as Vdc is varied from 0 to 2 V.




Note:- DUT = Device Under Test (Solar cell in this case)

# Solar Cell C-V Measurement

For the above circuit, the ac gain from $V_{DUT}$ to $V_{out}$ is given by,

$$\left|\frac{V_{out}}{V_{DUT}}\right| = \frac{C_{DUT}}{Cfb}\frac{1}{\sqrt{1+\frac{1}{\left(\omega RfbCfb\right)^2}}}$$

- Vary the dc voltage in steps from 0 volt to 2 volt and plot $C_{DUT}$ versus applied DC voltage.
- Plot $\frac{1}{C^2}$ vs $V_{DUT}$ and obtain the following:
  - Doping Density $N_D$( in terms of atoms/$cm^3$)
  - Built in Voltage $V_{bi}$

  you can use the following equation:

$$\frac{1}{C^2} = \frac{2}{q\varepsilon N_D}(V_{bi} - V_R)$$

where C is normalised junction capacitance $= C_{DUT}$/Area
consider Area $= 1\mu$m x $1\mu$m (Hypothetical value)
$V_R$ is Reverse diode voltage($=V_{DUT}$) and
$\varepsilon = \varepsilon_0 * \varepsilon_{si}(\varepsilon_{si} = 11.68)$