# Homework 2 (60 pts)

ENERGY 293 - Energy storage and conversion: Solar Cells, Fuel Cells, Batteries and Supercapacitors

Fall Quarter 2018

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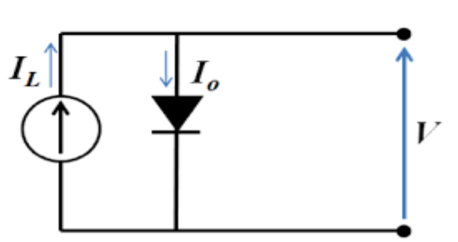
Due Oct. 25, 2018 at 3pm (Electronic pdf copy on CANVAS and hard-copy to (one of) the TAs)

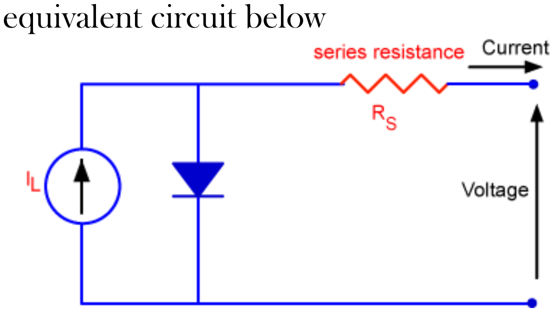
1. (10 pts) The power in a solar cell is given by P=IV, where V is the laod voltage and I is the load current obtained by modeling the solar cell from the circuit below:




Find the solution of the maximum power points (Vmax, Imax).

NOTE: The voltage (Vmax) that give maximum power depends on Voc

2. (10 pts) Find the analytical expression of the series resistance of the solar cell modeled through the equivalent circuit below



3. (40 pts) The Solarex MSX 60 module provides 60 watt of nominal maximum power, and has 36 series connected polycrystalline silicon cells. The key specifications are shown the table below (assumed at STC):

| Parameter | Variable | Value |
|---|---|---|
| *Maximum Power* | $P_m$ | 60W |
| *Voltage@ $P_m$* | $V_m$ | 17.1V |
| *Current @ $P_m$* | $I_m$ | 3.5A |
| *Short circuit current* | $I_{SC}$ | 3.8A |
| *Open-circuit voltage* | $V_{OC}$ | 21.1.V |

Implement the ideal PV cell using Matlab (Matlab code must be submitted with the solution).

Your program should be able to calculate the current I, using typical electrical parameter of the cell ($I_{sc}$, $V_{oc}$), and the other variables such as Irradiation (G), Temperature (T) reverse saturation current ($I_0$).

NOTE

The light induced current, $I_L$, or photocurrent, depends on the irradiance and temperature according to the following model

$$I_L = \frac{G}{G_{ref}}\left(I_{L,ref} + \mu_{sc} \cdot \Delta T\right)$$

Where you can assume $\mu_{sc} = 1.3x10^{-3}\ (\frac{A}{K})$, $\Delta T = T - T_{nom}$, with $T_{nom} = 298\ K$, and reference irradiance $G_{ref} = 1000\ W/m^2$ (STC).

The reverse saturation current of the pn junction is given by:

$$I_0 = I_{o,ref} \cdot \left(\frac{T}{T_{nom}}\right)^3 \cdot \exp\left(\frac{qE_q}{k} \cdot \left(\frac{I}{T_{nom}} - \frac{1}{T}\right)\right)$$

You can consider $I_{o,ref} = 4 \cdot 10^{-11} A$, and band gap energy $E_q = 1.16eV$.

Simulate the ideal solar cell for values of irradiance $G$= [200, 400. 600. 800, 1000] and temperature T=25°C, 30°C, 40°C and 50°C.

Simulate the same PV cell considering now a series resistance $R_s$ of 1.2 Ohm and a shunt resistance $R_{sh}$ of 50Ohm.

Comment your results.