Homework 1

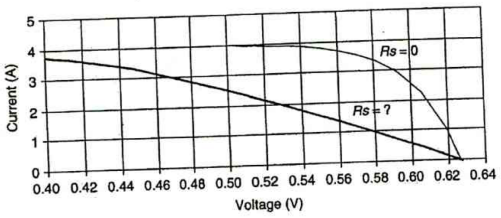
Problem 1. [**5 points**] Gallium Arsenide has a band gap of 1.42 eV. What maximum wavelength can a photon have to create electron-hole pairs?

Problem 2. [**20 points**] Let us explore the design of a PV system for Las Vegas, NV to deliver 4000 kWhr/yr. Las Vegas is known to receive 6.4 kWhr/m^{2}day of average annual insolation and it has an average ambient temperature of 26.9°C. Answer the following questions:

1. What should the AC rated power of the system be?
2. Estimate the DC power of the system under standard test conditions given the following information: i) The modules operate nominally at 45°C and the maximum power of the modules drops by 0.36%/°C above 25°C, ii) Losses due to dirt are 3%, losses due to mismatched modules are 3%, and the inverter efficiency is 92%.
3. If the PV modules are 13% efficient, what is the required area for the system?
4. Suppose the installed cost of the system is \$6 per DC Watt, and the system is paid for with a 30-year loan at 6% interest rate. Las Vegas offers a renewable energy credit that pays the owner \$0.05/kWhr generated. What is the cost of electricity generated in year 1?

Problem 3. [**8 points**] The figure below shows the $I-V$ curves for two cells. Answer the following questions:

1. Estimate R_{s} for the cell with $I-V$ curve labelled as R_{s} =?
2. Estimate R_{p} for the cell with $I-V$ curve labelled as $R_{\mathrm{s}}=0$.
3. Estimate the maximum power that can be delivered by the cell with $I-V$ curve labelled as $R_{\mathrm{s}}=0$.
4. Consider the cell with $I-V$ curve labelled as $R_{\mathrm{s}}=0$. Sketch the $I-V$ curve that would be obtained by connecting 5 parallel strings each with 10 series-connected cells of this type.



Problem 4. [**2 points**] We wish to deliver maximum power to a 12 V battery from a PV resource with the following characteristics: Open-circuit voltage 41 V, short-circuit current 6 A, maximum-power point voltage 40 V, and maximum-power point current 5 A. Pick a DC-DC converter topology to accomplish this and indicate the duty cycle at which the converter would have to be operated for the task.

Problem 5. [**5 points**] A grid-connected PV array consists of sixteen Shell SP150 modules that can be arranged in a number of series (S) and parallel (P) configurations: (16 S, 1 P), (8 S, 2 P), (4 S,

Table 1: Specifications of PV module and inverter

(a) Shell SP150 Module

Specification	Value
Rated power	150 W
Voltage at max power	34 V
Current at max power	4.40 A
Open-circuit voltage	43.40 V
Short-circuit current	4.80 A
Efficiency	11.4 %

(b) Sunny Boy SB2500 Inverter

Specification	Value
AC Power	2500
AC Voltage	198-251 V
MPPT voltage range	250-550 V
Max input voltage	600 V
Max input current	11 A
Efficiency	94 %

4 P), (2 S, 8 P), (1S, 16 P). The array delivers power to a Sunny Boy SB2500 inverter. Using the specifications of the PV modules in Table 1 (a), and the specifications of the inverter in Table 1 (b), what series-parallel configuration of modules would deliver maximum power to the inverter?
Circle the right answer and provide an explanation for your choice:

1. (16 S, 1 P)
2. (8 S, 2 P)
3. (4 S, 4 P)
4. (2 S, 8 P)
5. (1S, 16 P)
6. None of the above.

[**Note.** To clarify the notation, (2 S, 8 P) corresponds to the case that the array is built with 8 parallel strings and each string has 2 modules connected in series.]