Solar Cell Design and Processing – Fall 2004

Homework #3 - Due: 2 December 2004

Finally, you have to match the solar cell output with the motor to find a peak power combination – knowing that the torque and rotation rate can change the power delivered by the motor.

You have these goals:

- **Goal 1:** Find the matching point where a specific solar cell will maximize its output to a specific electric motor.
- **Goal 2:** Find the sunlight brightness dependence of goal 1 – i.e. plot the peak motor power output as a function of sunlight brightness, ranging from 5% to 100% of full sunlight.
- **Goal 3:** Work with the solution found in Goal 2: plot the torque provided when operating at peak power output -- as a function of sunlight brightness, ranging from 5% to 100% of full sunlight.
- **Goal 4:** Work with the solution found in Goal 2: plot the rotation rate provided when operating at peak power output -- as a function of sunlight brightness, ranging from 5% to 100% of full sunlight.

The Solar Cell specifications are drawn from the solar cells that we will be using – but simply be the IV specs for a single large cell. These data are contained in the example data set at the website.

The DC motor's specs at 0.5 volts are:

- Stall torque = 0.08 Newton-meters (Nm)
- No-load rotation rate = 100 RPM (this will need to be converted to radians per second when calculating power for the motor: Power = I*V and Power = T*w – both should be calculated in watts.)

Procedural Advice and Assumptions:

1. Read the motor information from the solar class website – look at the new version since there were a couple equation typos that were corrected.

2. Assume that the power generated by the solar cell will be used completely by the motor and be converted to mechanical power. So, cell power (I*V) must equal motor power (T*w).

3. Recognize that the solar cell and motor will be connected together without any other circuit elements – that means that the voltage from one will be the same as the voltage for the other.

4. Solve for the matching point where power and voltage will both be the same for solar cell and motor. This might be done graphically in P-V space (that's how I think anyway), but it could also be done analytically if you fit the main part of the solar cell curve to be some representative function.

5. Calculate the torque and rotation rate that will be defined by that P-V combination. Together these data (4 and 5) satisfy Goal 1 above.

6. Assume that the I-V relationship will simply be compressed downwards when the light level is lower. Assume that this compression will be strictly linear – so a 90% light level will have current values that are $0.90*I_i$ – the individual current entries in the table. You can use the spreadsheet to build columns at each of the light levels that you want to test. You should have solutions for each 5% increment in light level.

7. Solve number 4 again for each of the light levels and create a plot with Peak Motor Power Output as a function of light level ranging from 5 to 100% -- This then satisfies Goal 2 above.

8. Calculate the torque that would be used/generated under the peak power conditions specified in 7 – make a plot as a function of light level – same axes. This then satisfies Goal 3 above.

9. Calculate the spin speed that would be used/generated under the peak power conditions specified in 7 – make a plot as a function of light level – same axes. This then satisfied Goal 4 above.