MEC316 Tutorial Sheet 2

1) Show that the open circuit voltage of a simple array comprising two solar cells in parallel can be approximated by: **(2001 exam)**

$$V_{oc} \approx (kT/e)\ ln[I_L/I_0]$$

where I_L is the sum of the short circuit currents of the two cells under illumination and I_0 is the sum of the dark currents of the two cells.

Two cells are connected in parallel and operated at an ambient temperature of 27°C. Under illumination, the first cell has an open circuit voltage of 0.6V and a short circuit current of 1.5A. The second cell has corresponding values of 1.2V and 1.3A.

What is the open circuit voltage and short circuit current of the array under this illumination? Estimate the maximum power this array can develop.

2) A particular solar cell has a measured dark current of 2×10^{-10}A. When operated in sunlight and connected to a resistive load, R_L, of resistance 2Ω, the voltage across the load is found to be 0.5V. Estimate the photocurrent generated by the cell under these conditions, assuming that the temperature is 295K. **(1996 exam)**

Estimate whether the 2Ω load is optimum for maximum power output for this cell under this illumination condition.

The cell described in Question 2 above is now operated on a very cold day where the temperature is −10°C but the level of illumination is identical. Describe qualitatively what we might expect to happen to the power delivered by the cell.

3) Show that the voltage, V_m across a cell developing maximum power obeys the equation: **(2000 exam)**

$$\ln\left(\frac{eV_m}{kT}\right) \approx \ln\left(\frac{I_{sc}}{I_o}\right) - \frac{eV_m}{kT}$$

(Hint: assume that $V_m >> kT/e$)

A solar cell with $I_o = 10^{-10}$A has a short circuit current, I_{sc} = 50mA at room temperature. Use the expression above to estimate V_m. (Assume that kT/e = 25mV at 300K)

Hence determine the maximum power this cell can develop.
How do you arrange for the cell to develop maximum power?
What is the optimum value of load resistor we should use?
Estimate the fill-factor of the cell and comment on its value.

4) Draw a possible equivalent circuit for a solar cell and derive expressions for (i) the open circuit voltage and (ii) the short circuit current. **(1997 exam)**

A solar cell of area 25mm x 25mm square has an open circuit voltage of 0.5V when operated at 20°C in AM1 light. When operating into a resistive load under identical illumination, the cell output voltage drops to 0.45V. The dark current of this cell is 2 x 10^{-10}A. What is: (i) the load current, (ii) the power supplied to the load ,and (iii) the efficiency of the cell assuming the AM1 illumination is equivalent to 1kW/m^2.

5) A silicon solar cell and an AlGaAs solar cell are connected in parallel and undergo the same illumination at 300K. Under such conditions, the silicon cell by itself has an open circuit voltage of 0.7V and a short circuit current of 1.4A. Similarly, the AlGaAs cell by itself has an open circuit voltage of 1.0V and a short circuit current of 1.3A. What is the open circuit voltage and short circuit current of this simple combined array? **(1998 exam)**

From its I-V characteristics, estimate the maximum power developed by the array.

What is the fill factor for this array?

6) Show that maximising the power delivered by a solar cell leads to the expression:

$$\left(1+\frac{eV_m}{kT}\right)exp\left(\frac{eV_m}{kT}\right)=1+\frac{I_{SC}}{I_0}$$

where V_m is the voltage for maximum power, I_{SC} is the magnitude of the short circuit current and I_0 is the reverse saturation diode current. **(1995 exam)**

A particular solar cell with I_0 = 1nA is illuminated at 300K such that the short circuit current is 100mA. Use an iterative technique to solve the above equation and thereby determine V_m.

What is the maximum power output of the cell at this illumination?

7) A simple photovoltaic array comprises two ideal solar cells in parallel. Derive the open circuit voltage and short circuit current for this array. **(1999 exam)**

Under room temperature conditions, the first cell has a dark current I_{01} of 40pA and the second cell has a dark current I_{02} of 500pA. The corresponding short circuit currents under illumination, I_{L1}, I_{L2} are 250mA and 100mA respectively. What is the maximum power which this array can deliver and what is the optimum load resistance?
Estimate the fill factor for this cell.