NATIONAL UNIVERSITY OF SINGAPORE

Department of Electrical Engineering

EE2022 ELECTRICAL ENERY SYSTEMS

(Tutorial # 5)

1. A photovoltaic cell has a surface area of 100-cm^2, reverse saturation current $I_0 = 2 * 10^{-12}$ A/cm^2. In full sun it produces a short-circuit current of 20mA/cm^2 at 25°C.
   (a) Find the open circuit voltage at full-sun.
   (b) Find the open circuit voltage at 50% sunlight.

2. For the simple equivalent circuit for a 0.005m^2 photovoltaic cell shown in Fig. Q2., the reverse saturation current is $I_o = 10^{-9}$A and at an insolation of 1-Sun the short-circuit current is I_{sc} = 1A,. At 25°C, find the following:
   (a) The open circuit voltage.
   (b) The load current when the output voltage is V = 0.5V.
   (c) The power delivered to the load when the output voltage is 0.5V.
   (d) The efficiency of the cell at V = 0.5V.

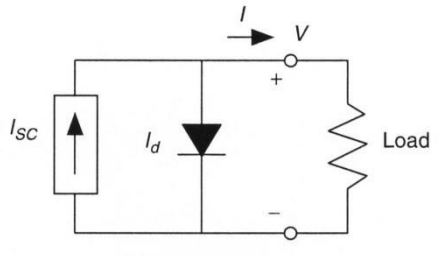

Fig. Q2

3. A PV module is made up of 40 identical cells, all wired in series. With 1-sun insolation (1 kW/m^2) each cell has a short circuit current I_{SC} = 4A and at 25°C its reverse saturation current is $I_0 = 10^{-9}$ A. If each cell is represented by the equivalent circuit shown in Fig. Q3, where parallel resistance R_P = 5 Ω and series resistance R_S = 0.01 Ω, find the voltage, current and power delivered by the module when the junction voltage is 0.5V.

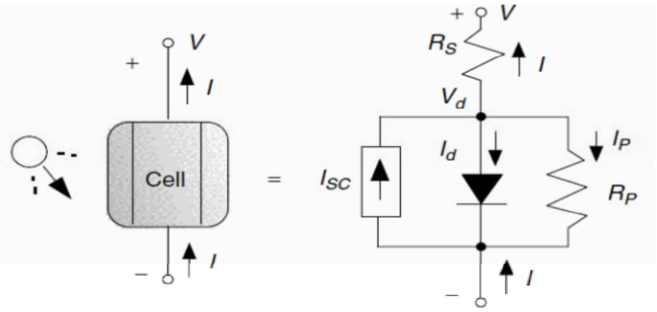

Fig. Q3

4. A horizontal-axis wind turbine with rotor diameter of 20 meters is 30% efficient in 10 m/s winds at a height of 10 m, 1 atmosphere of pressure and 15°C. The air density is 1.225 kg/m^3.

   (a) How much power will it produce in those winds?
   (b) Estimate the power that this wind turbine will produce at 250 meter mountain top if the air density is 1 kg/m^3 and friction coefficient α=0.3, assuming its efficiency is not affected by air density.

5. An anemometer mounted at a height of 10 m above the surface with crops, hedges and shrubs shows a wind speed of 5 m/s. The turbine is mounted at 60 m above the ground, and the rotor diameter is 60 m as shown below. For surface with crops, hedges and shrubs, 0.2. Assuming 15°C and 1 atmosphere pressure, determine:

   (a) the wind speed and the specific power in the wind at the highest point that a rotor blade reaches.
   (b) wind speed and the specific power at the lowest point that the rotor tip falls to. (c) Discuss the effect of this difference in speed on the turbine.

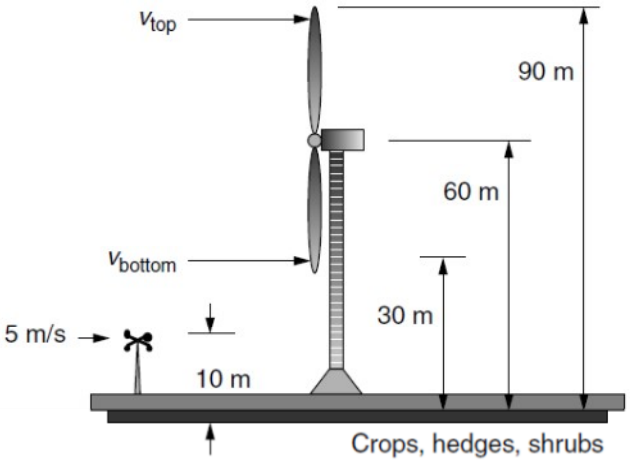

Fig. Q5