EE4404 Tutorial questions on solar PV

Q.1 Explain how crystalline Silicon converts sunlight into electricity in PV cells.

Q.2 What is the theoretical maximum conversion efficiency of Silicon based solar PV cells? Explain the reason behind this.

Q.3 What are the various losses in PV cells which reduce the conversion efficiency below the theoretical maximum efficiency?

Q.4 Draw the complete equivalent circuit of the solar PV cell. Explain the principle behind each component in the equivalent circuit.

Q.5 Find the open circuit voltage of solar PV cell with the following information given. Ambient temperature 40°C. Boltzmann constant k= 1.381 X 10^{-23}, charge of electron q=1.602X10^{-19} C. Short circuit current is 4A and the reverse saturation current is 10^{-10} A.

Q.6 A solar PV module with 32 cells in series supplies 2A to a 5Ω load. The ambient temperature is 25°C. The parallel and series resistors in the PV cell equivalent circuit are 10Ω and 0.1Ω respectively. The reverse saturation current of the junction is 10^{-10}A. Determine the short circuit current of the cell.

Q.7 The loss due to series and parallel resistors in the equivalent circuit of the PV cell are less that 1 percent. Determine the limits of their values if the $V_{OC} = 0.6\ V$ and $I_{SC} = 4\ A$.

Q.8 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 short-circuit current I_{SC} = 4 A and at 25°C its reverse saturation current is $I_0 = 10^{-10}$ A. Parallel resistance R_P = 6 Ω and series resistance R_S =0.01Ω.

Find the voltage, current, and power delivered when the junction voltage of each cell is 0.60 V.

Q.9 A PV cell output can be approximated to be linear from the maximum power point till the open circuit voltage. MPP voltage and current are: V_p = 0.5 V and I_p = 4 A. The open circuit voltage V_{OC} = 0.6 V. Determine operating point if a 1 Ω resistor is connected to the PV cell.

Q.10 What constitute standard test conditions (STC) for solar PV cells?

Q.11 How does solar insolation affect the short circuit current and open circuit voltage of the solar PV cells?

Q.12 Explain the effect of partial shading in solar PV modules? How is the effect mitigated in practical circuits?

Q.13 A 40-cell PV module has a parallel resistance per cell of R_P =5 Ω where as the series resistance is R_s=0.01Ω. In full sun and at current I = 3 A the output voltage was found there to be V = 24 V. If one cell is shaded and the current somehow stays the same, then:

a. What would be the new module output voltage and power?

b. What would be the voltage drop across the shaded cell?

c. How much power would be dissipated in the shaded cell?

Q.14 Using block diagram show the components of a stand-alone Solar PV system for a remote home. Describe the function of various components.

Q.15 A remote home uses following appliances daily.

Appliance	**Rating(W)**	**Daily usage duration (hours)**
TV	100	10
Lights	50	12
Fan	100	20

Design the size of the solar PV panel and the battery capacity in Ah if the 12V battery is supposed to store energy for about 3 days. Assume that the battery can be discharged up to 80% of its storage capacity. The location has 5 peak-sun hours on an average. Assume full-sun insolation is $1kW/m^2$.

Q.16 What are the various causes for the losses in output power in a PV system?

Q.17 Using detailed block diagram, show the components of a grid-connected solar PV system. Describe the function of each component.

Q.18 Describe the operation of buck-boost converter used for MPPT operation in solar PV system.

Q.19 Under certain ambient conditions, a PV module has its maximum power point at V_m = 16 V and I_m = 4 A. What duty cycle should an MPPT buck-boost converter have if the module is delivering the same power to a 1Ω resistance?

Q.20 A PV panel under standard test conditions produces an output of 1000W. The output drops by $0.5\%/^0C$ due to temperature rise and 5% due to dirt accumulation on it. The ambient temperature is 45^0C. Assuming power converter efficiency of 90%, determine the expected maximum AC power output from the panel.

Q.21 If a small remote community requires 1MWh/month, determine the area of standard solar PV panels required. State the assumptions made in your calculation.