UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2018

Course: Solar Cell Technology (ELEG- 432) **Semester: VI**
Program: B. Tech- Instrumentation and Control
Time: 03 hrs. **Max. Marks: 100**

Instructions: Attempt all the sections.

SECTION A (20 Marks)

S. No.		Marks	CO
Q 1	Explain the mismatch losses in series, parallel and series-parallel solar PV module.	**4**	**CO1**
Q 2	Draw the current-voltage (I-V) and Power-Voltage (P-V) characteristics of photovoltaic module. Show the impact of irradiation and temperature on the PV module power performance.	**4**	**CO2**
Q 3	A solar cell has the following parameters: $V_{OC} = 0.6V$, $I_{SC} = 30mA/cm^2$, fill factor= 76% and area of cell 12x12 cm^2 @STC. What will be the efficiency?	**4**	**CO2**
Q 4	Calculate the zenith angle for following values of air mass as, (i) AM= 1.5.(ii) AM= 2	**4**	**CO1**
Q 5	Briefly define (a) PV cell, module and array system (b) Series, parallel and total –cross-tied interconnections of PV module	**4**	**CO3**

SECTION B (40 Marks)

	Answer any four questions.		
Q 6	Calculate the efficiency and peak power of Silicon solar cell operating temperature at 27°C, with short circuit current of 2.2 A, and operating under standard solar irradiation of 1000W/m^2. The area of the solar cell is about 100 cm^2.	**10**	**CO2**
Q 7	Analyze the importance of site survey for PV plant installation in terms of (i) Solar irradiation availability (ii) dust samples (iii) PV array mounting type (iv) sun path.	**10**	**CO3**
Q 8	Evaluate the monthly average clearness index for 10 April, 2002, at a surface located at latitude 40°N. The monthly average daily terrestrial radiation on a horizontal surface is 28.1 MJ/m^2/day.	**10**	**CO1**
Q 9	Analyze the operation of stand-alone PV system assisted applications for (i) solar street light system (ii) solar PV assisted water pumping system. Draw the schematic diagram for both applications.	**10**	**CO4**
Q 10	Show the effect of partial shading on PV array system performance with the help of P-V and I-V curves and discuss all the possible causes of shading effect. What is the role of electrical connections of PV module to form series, parallel, series-parallel and total-cross-tied PV array in the context of shading effect?	**10**	**CO3**

<table>
<tr><th colspan="4">SECTION-C (40 Marks)</th></tr>
<tr><td>Q 11</td><td>A solar PV plant installation company has queried to design a stand-alone solar power plant of 10 kW power capacity (approximate power capacity) for household applications. The installation company has 210W (Single solar cell specification I_m=6A, V_m= 0.5V) capacity of single PV module, which is comprised 70 numbers of series connected solar cells and each cell size is 15x15 cm^2. Calculate

(i) Total numbers of solar PV modules
(ii) Design the structure for series, parallel and series-parallel connected PV system
(iii) Required roof-top area for installation.</td><td>20</td><td>CO3</td></tr>
<tr><td>Q 12</td><td>Design a series connected layout of all the required PV modules and evaluate the power capacity of PV array system to be installed in 46 m^2 non-shaded area. The data sheet of single PV module is shown in Table- 1 as,

Table. 1: Data sheet of single PV module
<table><tr><th>Parameters</th><th>Values</th></tr><tr><td>Maximum power (P_{max})</td><td>230 W</td></tr><tr><td>Maximum voltage (V_m)</td><td>29.49 V</td></tr><tr><td>Maximum current (I_m)</td><td>7.80 A</td></tr><tr><td>Open circuit voltage (Voc)</td><td>37.20 V</td></tr><tr><td>Short circuit current (Isc)</td><td>8.39 A</td></tr><tr><td>No. of solar cells</td><td>60 (series connected)</td></tr><tr><td>Dimensions</td><td>1626 x 990 x 50 mm</td></tr><tr><td>Operating temperature</td><td>- 40 to + 90 °C</td></tr><tr><td>Series fuse rating</td><td>15 A</td></tr></table>
OR

Design a PV water pumping system, which is required to draw 25,000 liter of water every day from a depth of 10 meter. The data required for calculations is as follows,

• Amount of water to be pumped per day= 25000 liter
• Total vertical lift= 12 m (5 m- elevation, 5 m- standing water level, 2m – draw down)
• Water density = 1000 kg/m^3
• Acceleration due to gravity = g = 9.8 m/s^2
• Solar PV module used = 75 Wp
• Operating factor= 0.75
• Pump efficiency = 30%
• Mismatch factor= 0.85</td><td>20</td><td>CO4</td></tr>
</table>

QUESTION PAPER

Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2018

Course: Solar Cell Technology (ELEG- 432) **Semester: VI**
Program: B. Tech- Instrumentation and Control
Time: 03 hrs. **Max. Marks: 100**

Instructions: Attempt all the sections.

SECTION A (20 Marks)

S. No.		Marks	CO
Q 1	Draw the sun path diagram during the winter, spring and summer seasons.	**4**	**CO1**
Q 2	What are the challenges posted by the light concentration in a solar PV system? Which parameter is most significantly affected by the light concentration?	**4**	**CO1**
Q 3	Calculation of declination angle for the collector located in Bombay (19. 12N, 72.51 E), which is tilted at an angle of 30^o with the horizontal and is pointing due south on October.	**4**	**CO3**
Q 4	Calculate the value of air mass (AM) for the given zenith angle as, (i) Zenith angle (θ) = 48^o (ii) Zenith angle (θ) = 60^o	**4**	**CO2**
Q 5	Briefly define (a) Reflected radiation (b) Diffuse radiation (c) Total radiation	**4**	**CO3**

SECTION B (40 Marks)

	Attempt any four questions.		
Q 6	Silicon solar cell operating temperature at 35°C, with short circuit current of 2.2 A, and operating under standard illumination of 1000W/m^2. The area of the solar cell is about 100 cm^2. Evaluate the efficiency and peak power solar cell.	**10**	**CO2**
Q 7	What is the current worldwide production of solar PV modules and what is the expected growth of production in near future?	**10**	**CO3**
Q 8	Evaluate the monthly average clearness index for 12 May, 2015, at a surface located at latitude 30^o N. The monthly average daily terrestrial radiation on a horizontal surface is 30.6 MJ/m^2/day.	**10**	**CO1**
Q 9	Analyze the operation of stand-alone PV system assisted applications for (i) Solar power assisted for communication system (ii) Grid interactive solar PV power system. Draw the schematic diagram for both applications.	**10**	**CO4**
Q 10	Analyze the importance of site survey for PV plant installation in terms of (i) Solar irradiation availability (ii) dust samples (iii) PV array mounting type (iv) sun path.	**10**	**CO3**

SECTION-C (40 Marks)

Q 11	Design a series connected layout of required PV modules and evaluate the power	**20**	**CO3**

	capacity of PV array system to be installed in 150 m^2 useful area. The data sheet of single PV module is shown in Table- 1 as, **Table- 1:** Data sheet of single PV module **Module Type: RNG-150D** Max Power at STC (P_{max}) 150 W Open-Circuit Voltage (V_{oc}) 22.5 V Short-Circuit Current (I_{sc}) 9.05 A Optimum Operating Voltage (V_{mp}) 17.9 V Optimum Operating Current (I_{mp}) 8.38 A Temp Coefficient of P_{max} -0.44%/°C Temp Coefficient of V_{oc} -0.30%/°C Temp Coefficient of I_{sc} 0.04%/°C Max System Voltage 600VDC (UL) Max Series Fuse Size Rating 15 A Fire Rating Class C Weight 12kgs / 26.5lbs Dimensions 1000x990x35mm / 39.5x39x1.4in STC Irradiance 1000 W/m², T = 25°C, AM=1.5		
Q 12	Design a 210 W solar PV module, which comprised the series connections of solar cells. A single solar cell size 120 mm × 120 mm is considered, which delivers the maximum current (I_m) and maximum voltage 6A and 0.5V respectively at standard solar irradiation level 1000W/m^2. Calculate (i) Total area of solar PV module (ii) Number of solar cells (if connected in series) * ***Assume 60 cm is extra area in entire PV module*** **OR** Design a solar PV system wherein the load consists of a CFL, TV, FAN, Refrigerator and Computer. The system should allow the use of loads in the non-sunshine hours. The operating hours and the power rating of these loads are given in the Table- 2 as, Table- 2: The wattage rating in the number of hours of daily usage of the loads **Load** / **Watts** / **H/day** / **Number** / **Watt-Hr** CFL / 9 / 5 / 2 / 90 FAN / 60 / 8 / 1 / 480 TV (21") / 150 / 2 / 1 / 300 Refrigerator / 150 / 8 / 1 / 1200 Computer / 250 / 3 / 1 / 750	**20**	**CO4**