(14)

B.Sc. in EEE, 5th Semester October 11, 2023 **(Morning)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination	Winter Semester, A. Y. 2022-2023
Course No.: EEE 4535	Time: 90 Minutes
Course Title: Renewable Energy System	Full Marks: 75

There are 3 **(three)** questions. Answer all 3 **(three)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1 a) Define altitude angle, declination angle, and latitude angle with proper (3D) illustration. Establish the relationship between altitude angle, declination angle, and latitude angle. **8 (CO1, PO1)**

b) Given the geographical coordinates of IUT's mini solar plant (latitude: 23.99 degrees, longitude: 90.422 degrees) and a GMT time difference of +6 hours, along with the weather forecast designating April 13th as the warmest day of 2023, analyze the following aspects: **17 (CO2, PO2)**

I. Calculate the **declination angle** based on the provided data.

II. Find the **altitude angle** and **azimuth angle** for the sun at **3:00 P.M. solar time** at IUT. Explain the significance of these angles in the context of solar energy capture.

III. Calculate the **clock time for solar noon** at IUT. Discuss why knowing solar noon is crucial for solar energy systems.

IV. Find the method to calculate the **direct beam solar radiation** that is normal to the sun's rays at **noon** on a clear day at IUT on **April 13th**. Explain how this information can be used in optimizing solar energy generation.

Please provide detailed calculations and explanations for each of the above tasks.

2 a) Deduce the simple equivalent circuit of a solar PV cell. Then, modify this simple circuit to assemble a more accurate representation, highlighting the reasons for these modifications. Analyze how the accurate equivalent circuit influences the PV cell's current-voltage (I-V) characteristics and efficiency under varying conditions. Lastly, briefly discuss the practical significance of using this refined model in PV system design and optimization. **12 (CO1, PO1)**

b) A PV module comprises of 36 identical cells, 12 wired in series, then three parallel lines. With 1-sun insolation (1 kW/m^2), each cell has short-circuit current I_{SC} = 3.4 A, and at 25°C its reverse saturation current is $I_0 = 6 \times 10^{-10}$ A. Parallel resistance RP = 6.6 Ω and series resistance RS = 0.005 Ω. Find the voltage, current, and power delivered when the junction voltage of each cell is 0.50 V. Draw the I-V characteristics of the module. **13 (CO2, PO2)**

3 a) Explain the purpose of Maximum Power Point Tracking (MPPT) in PV modules and why it's crucial for optimizing power output. Analyze how DC-DC converters facilitate MPPT in PV systems by adjusting voltage and current. **10 (CO1, PO1)**

b) Deduce input impedance characteristics for different DC-DC converters when PV modules serve as the voltage source and explain how these input impedance values influence current-voltage (I-V) and power-voltage (P-V) curves of PV modules when DC-DC converters are used for MPPT. **15 (CO2, PO2)**

Necessary Equations

Declination angle:

$$\delta = 23.45 \sin\left[\frac{360}{365}(n-81)\right]$$

Altitude angle:

$$\beta_N = 90^\circ - L + \delta$$

Solar position at any time of the day:

$$\sin\beta = \cos L \cos\delta \cos H + \sin L \sin\delta$$
$$\sin\phi_S = \frac{\cos\delta \sin H}{\cos\beta}$$

Hour angle:

$H = \left(\frac{15^\circ}{\text{hour}}\right) \cdot$ (hours before solar noon)

if $\cos H \geq \frac{\tan\delta}{\tan L}$, then $|\phi_S| \leq 90^\circ$; otherwise $|\phi_S| > 90^\circ$

Equation of time :

$$E = 9.87\sin 2B - 7.53\cos B - 1.5\sin B \quad \text{(minutes)}$$
$$B = \frac{360}{364}(n-81) \quad \text{(degrees)}$$

Solar Time (ST) = Clock Time (CT) + $\frac{4\text{ min}}{\text{degree}}$(Local Time - Meridian Local longitude)$^\circ$ + E(min)

Clear sky radiation:

Attenuated solar flux:

$$I_B = Ae^{-km}$$
$$A = 1160 + 75\sin\left[\frac{360}{365}(n-275)\right] \quad (\text{W/m}^2)$$
$$k = 0.174 + 0.035\sin\left[\frac{360}{365}(n-100)\right]$$