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

Semester Final Examination
Course No.: EEE 4535
Course Title: Renewable Energy System

Winter Semester, A. Y. 2022-2023
Time: 3 hours
Full Marks: 150

There are 6 **(Six)** questions. Answer all 6 **(Six)** 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) Explain the operation with Advantages and Disadvantages of HAWT and VAWT. **9 (CO1, PO1)**

b) A 40-m, three-bladed wind turbine produces 600 kW at a wind speed of 14 m/s. Air density is the standard 1.225 kg/m$^3$. Under these conditions, **16 (CO2, PO2)**

I. Explain the concept of Tip Speed Ratio (TSR) and its influence on the rotor's revolutions per minute (rpm) in the context of the given wind turbine.

II. Calculate the rpm of the rotor when operating with a TSR of 4.0 and determine the tip speed of the rotor under the specified conditions.

III. Evaluate the gear ratio required to synchronize the rotor speed with the generator speed of 1800 rpm.

IV. Assess the efficiency of the complete wind turbine, considering the integrated performance of its components (blades, gearbox, generator) under the specified operational conditions.

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 36 identical cells, 12 connected 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) Briefly Explain the impact of tower height and number of blades in a wind turbine. **10 (CO1, PO1)**

b) Find the density of air at 1 atm and 30° C (86° F). An anemometer mounted 10 m above a surface with crops, hedges, and shrubs shows a windspeed of 5 m/s. Estimate the wind speed and the specific power in the wind at a height of 50 m. Assume 15° C and 1 atm of pressure. **15 (CO2, PO2)**

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| 4 | a) | Deduce the input and output power of a wind turbine. | 10 (CO1, PO1) |
| | b) | Describe different grid connections of wind power. Explain DC-AC-DC link with proper illustration. | 15 (CO2, PO2) |
| 5 | a) | Explain the operational principles governing the connection of a PV system to the grid without a battery, detailing the flow of electricity and the specific functions of each component. | 12 (CO1, PO1) |
| | b) | A household consumes 200 units of energy on an average in a month in Dhaka. Design a rooftop PV setup for net zero Energy. In Dhaka the $H_{atmin}$ = 4.58 kwh/m$^2$/day. | 13 (CO2, PO2) |
| 6 | a) | Explain the operational principles of connecting a PV system with a battery to the grid, highlighting the interactions between the PV system, battery, and the grid. Deduce the efficiency of such a system. | 12 (CO1, PO1) |
| | b) | Identify the types of batteries suitable for photovoltaic (PV) systems and recall the key reasons that make them suitable. Propose multiple ways of denoting battery capacity. Examine the concept of *C-rate* and its implications on battery capacity. | 13 (CO2, PO2) |