

- N.B.: 1. Q.1 is compulsory  
2. Answer any Three out of remaining Five questions  
3. Assume any suitable data wherever required but justify the same  
4. Use graph paper wherever necessary

- Q.1 Answer the following:
- (A) Draw I-V (current v/s voltage) and P-V (power and voltage) characteristics of a 315 Wp solar PV panel with  $V_{mp} = 36$  V and  $I_{mp} = 8.75$  A at (i)  $1000 \text{ W/m}^2$  (ii)  $600 \text{ W/m}^2$ . Clearly mark all essential parameters on characteristics. 05
- (B) Explain the role of renewable energy and energy storage systems in futuristic power system scenario. Describe the renewable energy policy adopted by India. 05
- (C) What are the different ways to use the solar thermal energy? Describe any one of them in short with the help of neat diagrams. 05
- (D) Explain the use of battery and ultra-capacitor as a hybrid energy storage system for electric vehicle application. 05
- Q.2 (A) If a 48V standalone DC solar PV (SPV) system with battery backup is to be designed for a residential load of 4 kWhr/day, calculate (i) SPV array capacity (ii) Number of series and parallel combination of PV panels of 315 Wp with  $V_{mp} = 36$  V,  $I_{mp} = 8.75$  A and efficiency of 16% at STC are used (iii) Approximate area occupied by SPV array (iv) 24 volts lead acid battery storage capacity in AHr (ampere hour). Assume suitable data if needed. 10
- (B) Illustrate a typical hybrid power generation system comprising of solar PV, Fuel cell, batteries and an ultracapacitor as the sources. Determine the power capacity you would propose for each one of the source if the net capacity of system is 20 kW and justify the same. Make necessary assumptions if needed. Explain role of each source in the system operation. 10
- Q.3 (A) Explain in brief about Wind Energy System. Draw the wind turbine characteristics. Explain the features of horizontal axis wind turbine and vertical axis wind turbine. Explain the working of WES grid interface schematic for any one typical power topology. 10
- (B) Explain the principles of following technologies:  
(i) Ocean Thermal Electric Conversion (ii) Wave Energy system 10
- Q.4 (A) Describe the working of a Fuel cell based power generation system with the help of neat diagram. What are the advantages and disadvantages of such system compared to a solar PV based power generation system. 10
- (B) State the various energy storage technologies used in power system. Describe the use of batteries and ultra-capacitors as energy storage system (ESS) in renewable energy system and compare their performance. 10
- Q.5 (A) Assume a 12 V lead acid battery with a nominal capacity of 100 AHr at the C10 rate. If the battery is charged at constant current of 8 Amps for 6 hours, calculate the SOC of the battery at the end of charging period (assume zero initial charge). If the battery then discharged at constant current of 10 Amps. for one hour, what will be the SOC at the end of discharging period. 08

- (B) Assume load profile of a commercial shop situated in Mumbai as given below: 12  
Load 1: Continuous lighting/fan load (9am to 9pm): 300 Watts ( at DC 24V)  
Load 2: DC Water pump (between 1pm to 2 pm): 350 Watts (at DC 24V)  
If a solar PV with a battery based off grid system needs to be designed for this application with two days of recharge following the 2 days of autonomy, then decide and recommend the following:  
(i) Battery: type, DoD, energy efficiency and size (capacity) in Ahr  
(ii) Solar PV array capacity on  $W_p$

- Q.6 (A) Explain with the help of suitable example, how energy storage helps to improve the reliability, stability and protection characteristics of renewable energy systems. 06  
(B) Compare various energy storage technologies and suggest suitable applications for each of them 06  
(C) What is Maximum Power Point tracking (MPPT)? Explain any one MPPT algorithm with hardware details. What is distributed MPPT? 08

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