

Date: 28th November 2016

Time: 0930-1230hrs

This paper contains Six (6) questions Answer any four (4) questions. All question carry equal marks.

Relative permittivity of free space (ϵ_0) = 8.854×10^{-12} F/m

Q1)

- i) A schematic diagram of a Conventional Thermal Power plant is shown in Figure Q1. Identify components 1-6 and briefly describes the operating principle of that power plant [6 Marks]

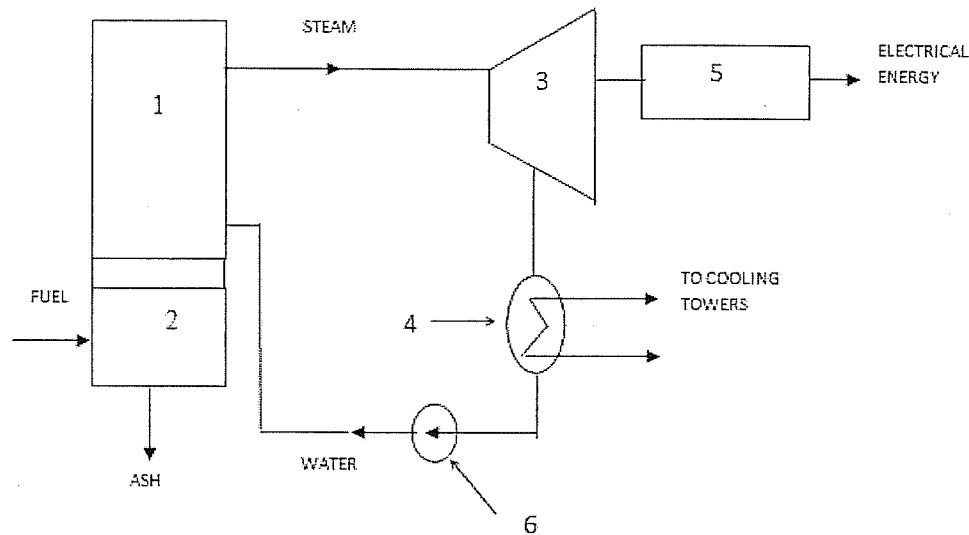


Figure Q1

- ii) It was observed that the total electrical energy requirement of a country for a particular year was 11962 GWh and 40% of energy generated through thermal power plants. Out of which, 12% generated by coal power plants and 28 % by Diesel power plants. If respective gross calorific values of Coal and Auto Diesel are 10500 kJ/kg and 44800 kJ/kg and efficiencies of two power plants are 39% and 38%. Calculate the kilograms of fuel used by each power plant for that year. [7 Marks]
- iii) Draw conceptual single line diagrams for both single busbar scheme and single busbar with bus sectionalizer. Explain briefly both busbar schemes and state what is the most reliable busbar configuration is. [7 Marks]
- iv)
- State the two types of voltage transformers used in metering and protection. [2 Marks]
 - Explain the operation of one of the above mentioned voltage transformers. [3Marks]

Q2)

- Explain why high voltages are used for the transmission of electrical energy. [2Marks]
- List three types of different insulators used in overhead transmission lines. Explain them briefly. [6Marks]
- Each conductor of a three phase high voltage transmission line is suspended by a string of four suspension type disc insulators. If the potential difference across the second unit from top is 13.2kV and across the third from top is 18kV, determine the voltage between conductors. [8 Marks]
- A 33kV, 50Hz, 4km long three phase underground cable uses three single core cables. Each of the conductor has a diameter of 2.5cm and the radial thickness of insulation is 0.5cm. The relative permittivity of the insulation is 3. Determine;

- Per phase Capacitance of the cable
- Per phase Charging current
- Total charging kVAR

[9 Marks]

Q3)

- List three types of distribution systems and briefly describe them [9 Marks]
- State three differences between the AC distribution system and DC distribution system [3 marks]
- A single phase AC distributor 'AB' is fed from end A and has a total impedance of $0.2 + 0.3j \Omega$. At far end, the voltage $V_B = 240V$ and the current is 100A at a p.f. of 0.8 lagging. At the midpoint M, a current of 100A is tapped at p.f. of 0.6 lagging with reference to the voltage V_M at the midpoint.
 - Calculate supply voltage V_A and phase angle between V_A and V_B [8 marks]
 - Draw phasor diagram to show all the voltages and currents. [5marks]

Q4)

- Explain briefly the importance of short circuit calculation in electrical power system. [3Marks]
- Unbalanced voltages of a three phase system are given as below. Calculate all the sequence components

a. $V_a = 230 \angle 25^\circ V$

b. $V_b = 192 \angle 75^\circ V$

c. $V_c = 120 \angle 165^\circ V$

[11Marks]

- In the single line diagram shown in figure Q4, each generators A and B are rated at 200 MVA, 33 kV and has reactance of 0.95 p.u. and are generating voltage of 1.05 pu. Transformers are rated at 150 MVA, 33 kV/132 kV and have reactance of 6% each. The transmission line has a reactance of 10.5Ω .
 - Convert all quantities to a common base of 300 MVA, and 132 kV on the line and draw the circuit diagram with values expressed in p.u. [6 Marks]
 - If three phase short circuit to ground fault occurs at the **quarter distance** of one of the transmission line from BUS 1 as shown in figure Q4, calculate the fault current in p.u. and its actual value. [5 Marks]

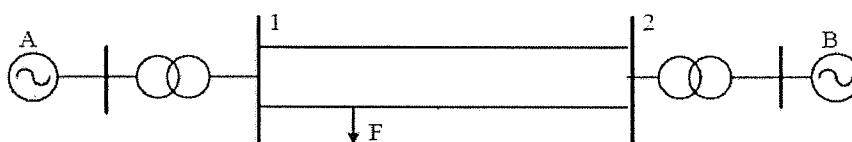


Figure Q4

Q5)

- Draw the sequence networks for generators with
 - unearthed star
 - solidly earthed star
 - impedance earthed star
- A single line diagram of a power system is shown in figure Q5. Reactances of the elements are given to common base values are indicated in the Table Q5. Current limiting reactor Z_n connected between the generator A and earth is $j0.315$ p.u.

[9 Marks]

Table Q5

Equipment	Positive sequence impedance	Negative Sequence impedance	Zero Sequence impedance
Generator A	$j0.4$	$j0.3$	$j0.08$
Generator B	$j0.3$	$j0.2$	$j0.05$
Transmission lines	$j0.4$	$j0.4$	$j0.7$
Transformers	$j0.15$	$j0.15$	$j0.15$

- a) Draw positive, Negative and Zero sequence networks for the Figure Q5 [9 Marks]
- b) Draw an equivalent sequence network when the fault at F is Single line to ground fault and calculate the p.u line fault current [7Marks]

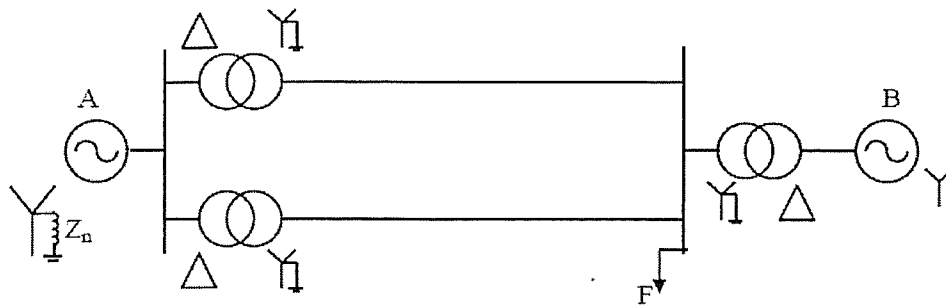


Figure Q5

Q6)

- i) An industrial factory, supplied with three phase, 400 V supply and having power factor of 0.85 lagging at the supply side has the electricity load curve as given below at working hours where T is time in 24 hour format.

$$\text{Load (L)} = (-150) + 30 \times T - T^2 \text{ in kW}$$

If factory works 12 hours [8.00 to 20.00] per day and it can be assumed that the load at non-working hours is 10 kW and 30 days per billing month.

For this factory;

- a) Find the maximum demand [3Marks]
- b) Calculate the cost for electricity per month [15Marks]
- c) If it is required to improve the power factor to the 0.9 lagging, calculate the required capacity of the capacitor per phase [4Marks]
- d) Find out whether there are any financial benefits of improving the power factor to the value of 0.9 lagging. [3Marks]

[Tariff plan of the Industrial customers metered at the 400/230 V is given by table Q6 in Annex I]

Customer Category I- 1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Customer Category I- 2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Table Q6

Customer Category	Energy charge (LKR/kWh)			Fixed Charge (LKR/month)	Maximum Demand Charge per month (LKR /kVA)	Fuel adjustment charge (% of Energy Charge)
	Peak (1830hr–2230hr)	Off-Peak (2230hr-0530hr)	Day (0530hr-1830hr)			
Industry						
I-1	12.50			600		15
I-2	21.00	7.00	11.30	3,000	1,100	15