**The Open University of Sri Lanka**
**Advanced Diploma in Technology**
**ECX4232-Power Systems I**
**Final Examination: 2015/2016**
**Duration: Three hours**
**Closed Book**

**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* $(\varepsilon_0) = 8.854x10^{-12}\ F/m$

**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]**

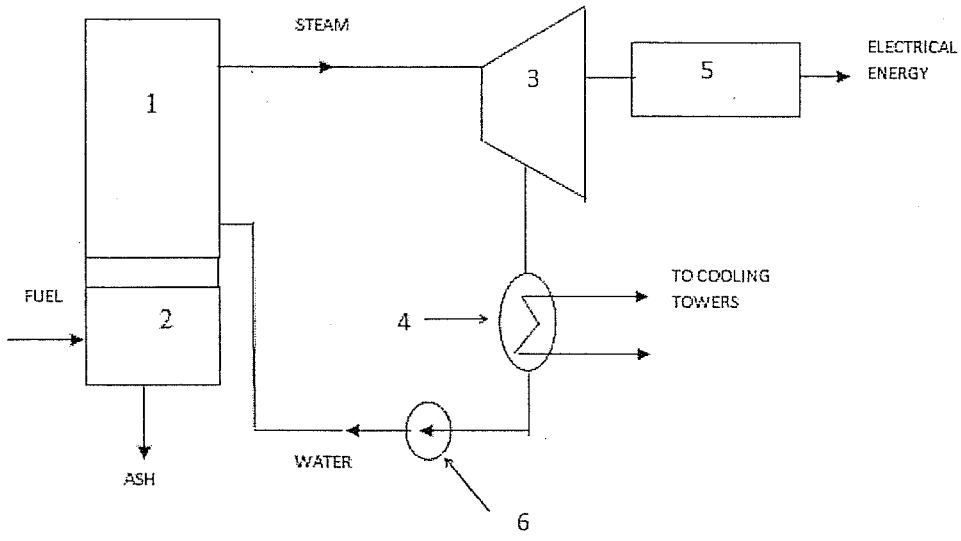


**Figure Q1**

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)

a) State the two types of voltage transformers used in metering and protection. **[2 Marks]**

b) Explain the operation of one of the above mentioned voltage transformers. **[3Marks]**

**Q2)**

i) Explain why high voltages are used for the transmission of electrical energy. **[2Marks]**

ii) List three types of different insulators used in overhead transmission lines. Explain them briefly. **[6Marks]**

iii) 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]**

iv) 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;

a. Per phase Capacitance of the cable
b. Per phase Charging current
c. Total charging kVAR

**[9 Marks]**

**Q3)**

i) List three types of distribution systems and briefly describe them **[9 Marks]**

ii) State three differences between the AC distribution system and DC distribution system **[3 marks]**

iii) 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.

a) Calculate supply voltage $V_A$ and phase angle between $V_A$ and $V_B$ **[8 marks]**

b) Draw phasor diagram to show all the voltages and currents. **[5marks]**

**Q4)**

i) Explain briefly the importance of short circuit calculation in electrical power system. **[3Marks]**

ii) Unbalanced voltages of a three phase system are given as below. Calculate all the sequence components

a. $Va = 230\angle 25\ V$
b. $Vb = 192\angle 75\ V$
c. $Vc = 120\angle 165\ V$

**[11Marks]**

iii) 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 10.5 Ω.

a) 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]**

b) 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]**

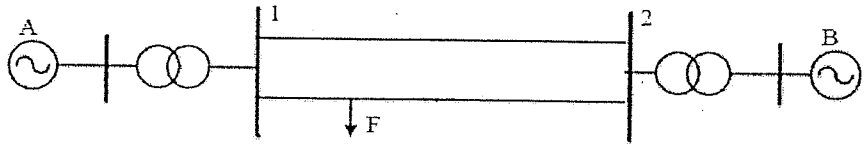


**Figure Q4**

**Q5)**

i) Draw the sequence networks for generators with

a) unearthed star
b) solidly earthed star
c) impedance earthed star

**[9 Marks]**

ii) 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 Zn connected between the generator A and earth is j0.315 p.u.

**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]**

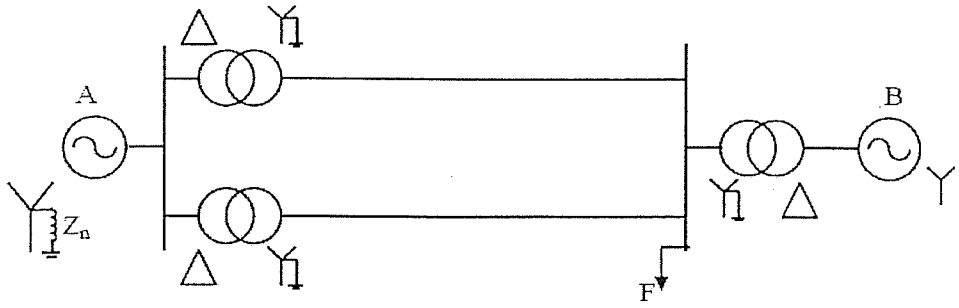


**Figure Q5**

**Q6)**

A three phase 50Hz overhead transmission line 100km long has the following constants

Resistance/km/phase = 0.1Ω

Inductive reactance/km/phase =0.2 Ω

Capacitive susceptance/km/phase = $0.04 \times 10^{-4}$ siemen

i) Using nominal T modal, Determine;

a) Sending end current **[8 Marks]**

b) Sending end voltage **[2 Marks]**

c) Sending end power factor **[2Marks]**

d) Transmission efficiency **[3Marks]**

When supplying a balanced load of 10000 kW at 66kV and 0.8 Power Factor lagging

ii) Draw the phasor diagram showing all voltages and currents **[10Marks]**