UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2023

Module Number: EE3304 **Module Name: Power Systems I**

[Three Hours]

[Answer **all questions**, each question carries 12 marks]

Q1 a) i) State four characteristics of a good power system.

ii) Explain the terms "load factor" and "Diversity factor".

iii) Consider a power system with three generators and three consumers. Rated output power of each generator is 50MW. Maximum demand values of the three Consumers are 60MW, 75MW and 40MW respectively. The daily demand profile of the three consumers for a day is given in Table Q1. Draw the load curve for the system and calculate average demand, demand factor, load factor and the diversity factor for the given day. Comment on the demand factor value of this power system.

[6 Marks]

b) The single-line diagram of a three-phase power system is shown in Figure Q1. The three-phase load absorbs 60 MVA at 0.75 power factor (lagging), and lines 1, 2, and 3 have the reactance of 40Ω, 32Ω, and 30Ω, respectively. Using 50 MVA and 20kV as base values at Generator 1, draw the per unit circuit diagram.

[6 Marks]

Q2 a) i) Name the two categories of energy resources, with examples for Sri Lanka.

ii) What is meant by "Energy Intensity" in a country?

Energy intensity values of two countries are as follows.

Country X: 20.2 toe/LKR million

Country Y: 9.8 toe/LKR million

Explain which country is using energy efficiently between X and Y.

iii) "Supplying electricity during peak hours is costlier than supplying electricity during off peak hours". Explain this statement using the typical demand curve of Sri Lanka.

[5 Marks]

b) i) Briefly explain the reason for using different types of fuels and technologies in power generation for a country?

ii) How does the diversity factor influence cost of electricity generation?

iii) Name the main organizations involved in electricity distribution in Sri Lanka along with their distribution areas and voltages utilized.

iv) What are the tariff schemes introduced for promoting roof top solar

installations in Sri Lanka? Briefly explain the difference between each of these schemes.

[7 Marks]

Q3 a) i) What is the purpose of a governing system in a power plant?

ii) Briefly explain the differences between reaction type and impulse type turbines with examples for each type of turbine.

iii) In a hydro-electric power plant, water flows from an elevation of 150m to a turbine. The head loss in the water conductor system is equal to 10m. The power plant is supplied from a reservoir with a catchment area of 1300km^2. The average annual rainfall in the catchment area is 150cm and 60% of this rainfall is allowed for power generation. The load factor of the plant is 60% and the turbine and generator efficiencies are 88% and 92% respectively. Calculate a suitable power rating for the plant and comment on the type of water turbine suitable for the power plant.

[6 Marks]

b) i) Draw a simple schematic diagram of a gas power station and name the main components.

ii) Why is it required to maintain the correct proportion of air and fuel mix into the furnace of a coal fired power station?

iii) Briefly describe two mitigation options for the environmental impacts caused by coal power stations.

iv) Compare the economic and environmental impacts of coal fired power stations and LNG fired power stations. Explain your recommendation between these two technologies for the present scenario of Sri Lanka with reasons.

[6 Marks]

Q4 a) i) State three actions that can be taken to handle increasing electricity demand.

ii) How does a dynamic tariff system help to achieve indirect load control?

iii) What is the impact of maximum demand to electricity cost of an installation?

iv) Briefly explain four demand side management techniques with suitable graphs.

[6 Marks]

b) i) What is an "Energy Audit".

ii) State four main areas of focus in a typical energy audit.

iii) A 3-phase, 50 Hz, 2400 V star connected induction motor with a power factor of 0.8 lagging and an efficiency of 90%, generates 450kW. A bank of capacitors is connected in delta across the supply terminals and power factor is raised to 0.95 lagging. Each of the capacitance units is built of 4 similar 600 V capacitors.

Determine the kVar rating of the capacitor bank and the capacitance of each unit. Calculate the saving on the electricity bill after the installation of capacitor bank if the charge per kVar is Rs. 60.00

[6 Marks]

Q5 a) i) What is the main objective of "Power System Protection"?

ii) What is meant by "Selectivity" and "Reliability" of a Power system protection equipment?

iii) Why does a Measurement Current Transformer get saturated earlier than a Protective Current Transformer?

iv) A Very Inverse (VI) type over current relay is connected to the power system through a 400/5 current transformer. Operating time of the relay (t) is given by the equation given below where TSM. is the time setting multiplier and PSM is the plug setting multiplier. The time setting multiplier of the relay is 0.7 and the relay operates in 2.36s during an over current fault. Calculate the current setting and the minimum current in the relay coil at which relay starts to operate the circuit breaker, during an over current fault of 3000A.

$$t = TSM \times 13.5/(PSM - 1)$$

[6 Marks]

b) i) What is "TN-S" earthing system? Explain with a suitable diagram.

ii) Comment on the cost and safety of "TN-S" earthing system compared to other earthing types with reasons.

iii) Explain the procedure of "Fall of Potential Method" used in measuring earth resistance.

iv) Prove that the earth resistance of a hemispherical electrode is given by the following equation. ρ is the resistivity of soil and r is the radius of the electrode.

$$R = \frac{\rho}{2\pi r}$$

Find the diameter of a hemispherical electrode which has an earthing resistance of 20Ω, buried at a surface of earth having a soil resistivity of 30 Ωm.

[6 Marks]

Table Q1: Daily demand profile of the three consumers

Time	Consumer 1 (MW)	Consumer 2 (MW)	Consumer 3 (MW)
12.00 midnight – 8.00am	-	40	-
8.00am – 2.00pm	50	60	25
2.00pm – 4.00pm	30	60	30
4.00pm – 10.00pm	40	-	-
10.00pm – 12.00 midnight	-	40	-

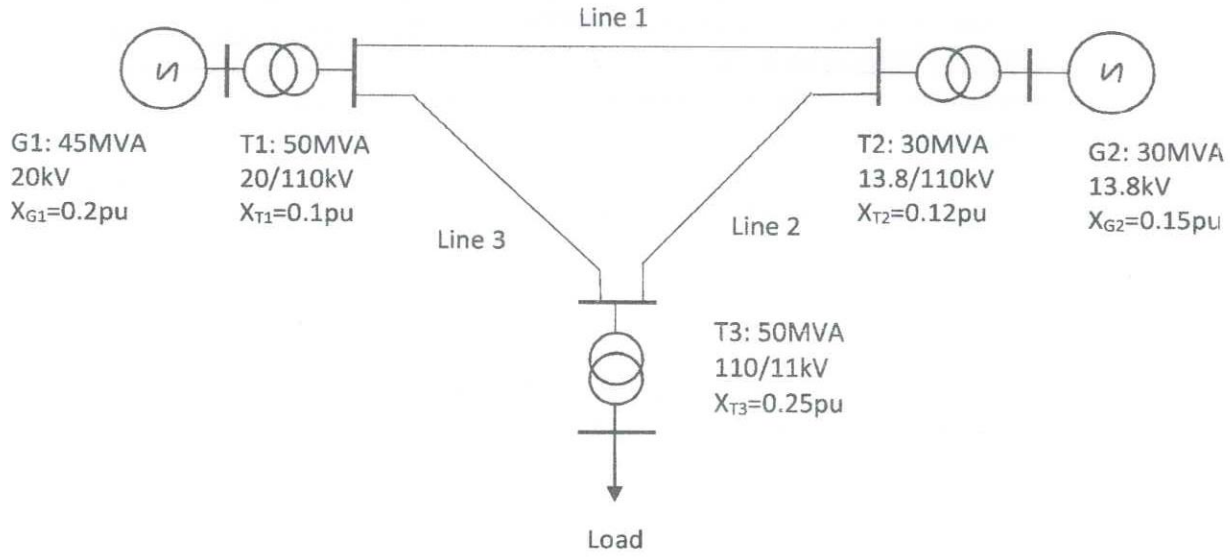

Figure Q1.