City& Guilds

9210-209
Level 7 Post Graduate Diploma in Engineering
Power System Economics and Planning

GUa d`Y˙DUdYf

.
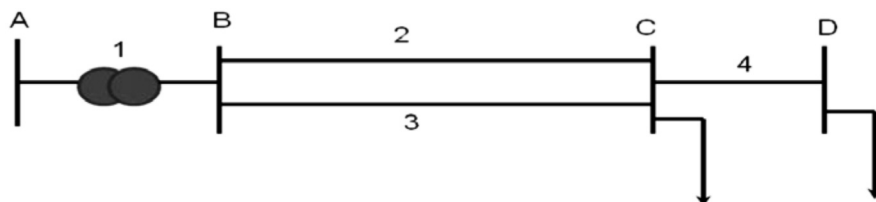
You should have the following for this examination
• one answer book
• non-programmable calculator
• pen, pencil, ruler

No additional data is attached

General instructions
• This paper consists of **eight** questions.
• Answer **five** questions only.

1   a)   What is meant by cost of un-served energy?   (4 marks)
    b)   Explain why long term generation planning is more important for a developing
         country than for a developed country.   (4 marks)
    c)   The maximum demand of a power system of an island which had no electricity
         before is estimated to be 50 MW with a load factor of 0.5. In order to meet this
         demand it is possible to install a sub-marine cable and purchase electricity from
         the utility operating in the mainland. This would cost a capacity charge of Rs.
         1000 per kW per month and an energy charge of Rs. 10.00 per kWh. There is an
         alternative proposal to construct a 70 MW coal fired power plant at the cost of Rs.
         300,000 per kW. The plant is financed by taking a bank loan at 10% interest for the
         100% of the cost. The loan is repaid within 10 years after the grace period (from 4th
         year onwards). Neither loan instalments nor interest is to be paid during the grace
         period which overlaps the construction period of the plant. The plant can be
         commissioned at the end of year 3. The plant has a lifetime of 30 years and
         negligible salvage value. Generation of a unit (kWh) requires 0.6 kg of fuel at
         the constant price of Rs. 3 per kg. Assume a variable maintenance cost of
         Rs. 1.20 per kWh and a fixed maintenance cost of Rs. 100 million per year.
         i)   In case the coal power plant is selected what is the total cost of operation
               (cost of fuel and maintenance) in the 4th year. Assume plant factor as 85%.   (4 marks)
         ii)   What is the simple payback period at constant prices of the coal power plant
               project if a constant selling price of Rs 10.00/kWh is achievable?   (4 marks)
         iii) Give your recommendation with reasons on selection or non-selection of the
               coal power plant?   (4 marks)

2   a)   Discuss the impact of the following on transmission network planning:
         i)   Prospective development of large wind parks away from the load centres.   (4 marks)
         ii)   Interconnections with neighbouring countries.   (4 marks)
         iii) Practices used to ensure adequate reliability of the network.   (4 marks)
    b)   A section of a high voltage transmission system with its associated failure rates
         and repair durations are given in Figure 2.1 and Table 2.1. Evaluate the availability
         of power at the load bus-bar D assuming 100% availability at A.   (8 marks)

Figure 2.1

Component	Failure rate (failures/year)	Repair duration (hr)
1	0.01	100
2	0.5	20
3	0.5	20
4	0.5	20

Table 2.1

2

3 a) Describe the merit order dispatch method stating its advantages and disadvantages. (5 marks)

   b) Three thermal power plants A, B and C jointly supply a load of 450 MW. The cost of production of generators as a function of the load taken are given below, where the generated quantities P_A, P_B and P_C are in MW and the total costs of generation $C(P_A)$, $C(P_B)$ and $C(P_C)$ are in Currency Units (CU) per hour:

$$C(P_A) = 225 + 8.0P_A + 0.0025P_A^2 \qquad 45\text{ MW} \leq P_A \leq 350\text{ MW}$$
$$C(P_B) = 729 + 6.3P_A + 0.008P_B^2 \qquad 45\text{ MW} \leq P_A \leq 350\text{ MW}$$
$$C(P_C) = 400 + 7.5P_C + 0.002P_C^2 \qquad 47.5\text{ MW} \leq P_A \leq 450\text{ MW}$$

   i)   Use the incremental cost method to find the optimum loading of the generators. (7 marks)
   ii) Calculate the total cost of production. (4 marks)
   iii) How would you incorporate the transmission losses into your calculation in i) above? (4 marks)

4 The daily load curve of a utility on an average day is estimated as given in Table 4.1.

Time of the day (hrs)	Demand (MW)
00:00 – 05:00	800
05:00 – 18:00	1200
18:00 – 21:00	2100
21:00 – 23:00	1200
23:00 – 24:00	800

Table 4.1

A mixture of power plants with total installed capacity of 3600 MW is available to serve this demand. According to performance statistics half of the total capacity is always available while the availability of capacity from 1800 MW to 2000 MW is estimated to be 0.9. Availability of capacity exceeding 2000 MW is just 0.8.

   a) Calculate the total demand per day. (4 marks)
   b) What is the expected number of days where the peak demand can't be met? (4 marks)
   c) Calculate the LOLP. (4 marks)
   d) What is the total un-served energy in a year? (4 marks)
   e) How would you correct your answer to d) above if the failures are more frequent during peak hours? (4 marks)

5 a) What are the methods available for neutral grounding in power systems? (4 marks)
   b) Using appropriate diagrams explain one and half breaker bus-bar system. (4 marks)
   c) Briefly explain the following:
       i)   Step potential and touch potential. (4 marks)
       ii) Purpose of auto-reclosing option of circuit breakers. (4 marks)
       iii) On load tap changing. (4 marks)

6 a) How does the no load loss of distribution transformers impact the total distribution losses in a rural area where load factors are relatively low? (4 marks)

   b) A distribution transformer is to be installed to serve a load having the following estimated daily profile, the power factor is assumed to be 0.8 lagging all the time.

   Time of the day   load (kW)
   00.00 to 06.00   20
   06.00 t0 18.00   40
   18.00 to 22.00   80
   22.00 to 24.00   20

   Two transformers T1 and T2 both rated at 100 kVA are available for selection for this application. The transformer T1 has a no load loss of 270 W and a full load loss of 2190 W. The transformer T2 has a no load loss of 340 W and a full load loss of 2580 W. The total loss L (in W) at the load of P kW is approximated by the equation
   $L = A + B \times P^2$
   Where A and B are constants for a given transformer.

   i)   Obtain the constants A and B for each of the transformers. (4 marks)
   ii) Calculate the annual transformer loss for each of the transformers. (4 marks)
   iii) What is the total saving to the utility over a period of 10 years if T1 is selected? Assume a constant price of 7 US cents per kWh. (4 marks)
   iv) How would you advice the utility in the transformer selection considering the life time cost of it? (4 marks)

7 a) Explain how electricity tariff can be used as a DSM tool. (4 marks)

   b) Explain the features of the following tariff mechanisms?
   i)   Block tariff. (2 marks)
   ii) Volume discriminated tariff. (2 marks)
   iii) Time of use tariff. (2 marks)

   c) An industrial consumer uses 2800 kWh during the system peak period falling from 1800 h to 2200 h in the evening. The total consumption within the 20 hours outside the peak period amounts to 2700 kWh. The industry works 26 days in a month. The local distribution company offers a choice of two electricity tariffs A and B, for industrial consumers described below (prices are given in currency units – CU):

	Tariff A	Tariff B
Fixed charge	450.00 CU/Month	450.00 CU/Month
Unit charge – peak	3.90 CU/kWh	5.50 CU/kWh
Unit charge – off peak	3.90 CU/kWh	3.60 CU/kWh
Monthly demand charge	210.00 CU/kVA	150.00 CU/kVA

   i)   Assuming that the load has a flat distribution during the peak and that the maximum demand occurs during the peak period, calculate the monthly electricity bills under tariff A and B separately. Assume a power factor of 0.8 lagging. (4 marks)
   ii) If the industrial consumer has the ability to shift 450 kW of load from the peak period to off peak by introducing an extra work shift, calculate the saving that could be achieved by selecting the tariff B. Clearly state the assumptions made in your calculation. (6 marks)

8   a)   What do you understand by 'deregulation of the electricity sector'?   (4 marks)
    b)   Write short notes on the following covering all important aspects under each
         of the topics.
         i)   Single buyer model for electricity markets.   (4 marks)
         ii)   Wheeling charges.   (4 marks)
         iii) Clearing price in the spot market.   (4 marks)
         iv)   Capacity charge in a power purchase agreement.   (4 marks)