The Open University of Sri Lanka
Bachelor of Technology
ECX 6332-Power Systems Planning
Final Examination 2009/2010

Duration Three Hours

Date: 23rd March 2010 Time: 1400-1700 hrs.

This paper contains Eight (8) questions. Answer any Five. All questions carry equal marks.

1) Three identical synchronous machines of rating 200 MW, 50Hz operating in parallel have the following characteristics.

Machine	Speed drop (R)	Speed changer setting
I	5%	60% rated load at rated speed
II	5%	80% rated load at rated speed
III	5%	70% rated load at rated speed

a) Determine the load taken by each machine for a total load of 420 MW and calculate the frequency of operation.
b) What adjustments should be made by the speed changers of the three machines to share the loads as in (a) but with a frequency of 50 Hz.

2) Consider a steam power generating station with two units. The input-output characteristics being specified by

$$F_1 = 80 + 8P_1 + 0.024P_1^2$$
$$F_2 = 120 + 6P_2 + 0.04P_2^2$$

In scheduling a load of 100 MW by equal incremental cost method, the incremental cost of unit # 1 is specified wrongly by 10% more than the true value while that of unit # 2 is specified by 6% lees than the true value.
Find:

i) The change in generation schedule
ii) The change in the total cost of generation

3) Fig. Q3 shows an annual load curve for a particular power system. Four power plants are available to meet this demand, the characteristics of which are shown in Table-Q3. Neglecting maintenance requirements of the power plants, develop & calculate:

- Load Duration Curve (LDC)
- Annual Energy to be served

Develop the Remaining Load Duration Curves (RLDCs) for each unit and estimate:

- LOLE (loss of load expectation)
- ENS (Energy not served)
- Energy served & production cost of each plant

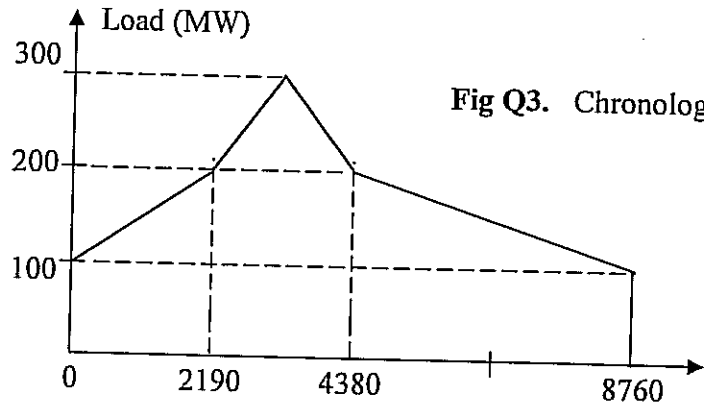


Fig Q3. Chronological Load Curve

Table Q3

Unit #	Type	Effective Capacity MW	Fuel Cost Rs/kWh	Variable Maintenance Cost Rs/kWh	Forced Outage Rate
A	Hydro-Electric (Run-of-River)	100	-	1.00	0.01
B	Thermal	100	5.50	2.50	0.05
C	Thermal	100	7.50	1.00	0.04
D	Thermal	100	7.80	1.00	0.06

4) Describe one of the following:

a) Renewable energy based generation options for Sri Lanka and their environmental impacts. Your answer should include brief explanation of technology, their development status, indicative economic merits, and any positive and negative environmental and social impacts.

b) Future thermal generation options for the Sri Lanka power system and their environmental impacts. Your answer should also include brief explanation of technology and indicative economic merits of each technology.

5) Define the terms Self-price elasticity of demand
Cross- price elasticity of demand

Self and cross-price elasticity of demand for diesel fuel in a country is as shown below:

	Price Change			
	Electricity	Gasoline	Diesel	LPG
Diesel demand	0.4	1.0	-0.2	0.0

i) Identify the possible reason for the above figures and their magnitudes, including ability for substitution.

ii) Estimate the change in demand for diesel, if the prizes of all the above energy products are increased by 10%.

6)

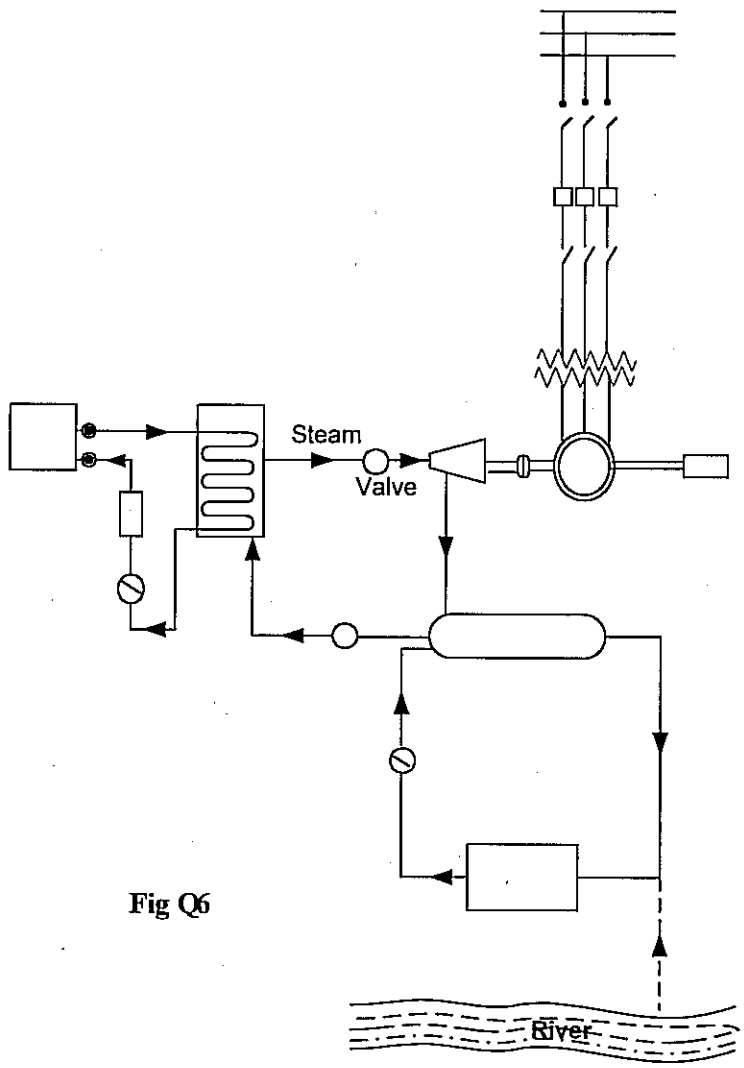


Fig Q6

a) The schematic arrangement of a nuclear power station is shown in figure Q6. The whole arrangement can be divided into the following stages:

i) Nuclear reactor	v) Feed water pump
ii) Heat exchanger	vi) Cooling water
iii) Steam turbine	vii) Alternator.
iv) Condenser	viii) Exciter

Re-draw the arrangement and identify the above stages.

b) Explain the word "Chain reaction" with respect to nuclear power generation

c) An automatic power reactor can deliver 300 MW. If due to fission of each atom of U_{92}^{235}, the energy released is 200 MeV, calculate the mass of Uranium fissioned per hour.

Assume that 1 eV= 1.6×10^{-19} J and 1 gram-atom = 6.023×10^{23} atoms.

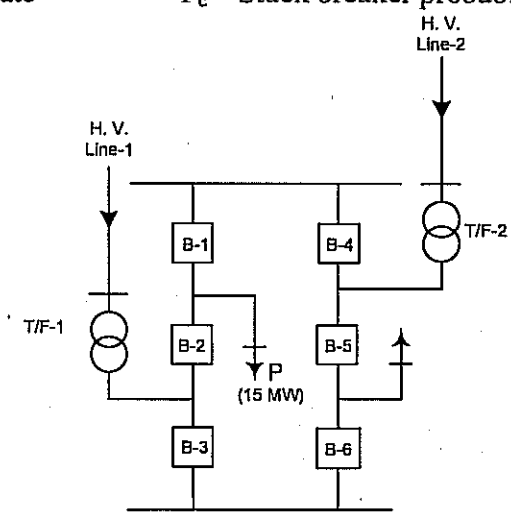
7. Evaluate the failure rate (λ), average outage time (r), annual outage time (U) and unserved energy of load point "P" of the one-and-half substation configuration shown below:
[Assume the reliability data of the components as given in the table. Consider only the overlapping forced outages up to second-order and first-order active failures.]

If stuck breaker conditions are also included in the analysis, what are the additional events you will find and re-compute the results with stuck breaker probability?

Reliability data

Component	λ (f/yr)	r (hours)	λ_a (f/yr)	s (hours)	P_c
H. V. Lines	0.1	10	0.1	0.5	-
Breakers	0.05	20	0.02	0.5	0.1
Transformers	0.01	50	0.01	0.55	-

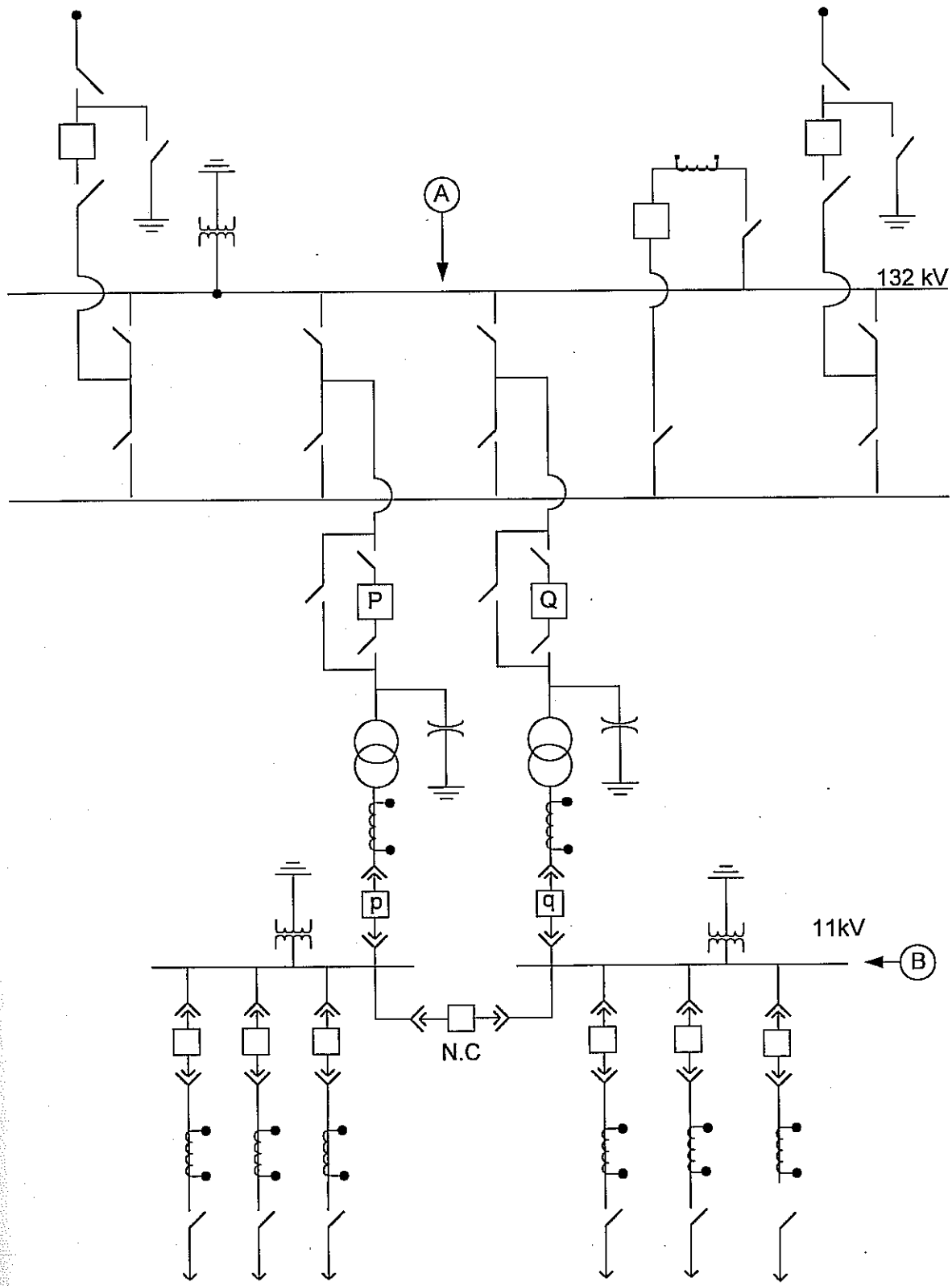
λ_a= Active failure rate P_c= Stuck breaker probability s = Switching time



One-and-Half breaker configuration

8. You are requested to submit the substation configuration given under Q#8 attached as Page [5] of [5] while answering this question.

1. Identify the H.V side bus-bar configuration and L.V. side bus-bar configuration.
2. Also identify each and every component shown the given figure Q#8
(You may mark it on the given figure Q#8 and attached with the answer script)
3. Identify the two by-pass isolators installed on the H.V side and explain the reason for installing the same.
4. Also explain the purpose of installing P&p Q&q H.V and L.V breaker on either sides of the power transformers.
5. Why do we have V.Ts and C.Ts. installed at some locations of the bus configuration?
6. If the rating of the 132/11 kV T/Fs are 30/40 MVA, OA/FA and the p.u. impedance is 12% based on its OA rating, what would be the L.V. breaker short circuit rating in terms of kA. (State any assumptions made)
7. Also, compute the minimum continuous 11 kV bus-bar rating, 11 kV bus-coupler rating and 11 kV feeder breaker rating. (State any assumptions made)



Substation Configuration for Q#8