THE INSTITUTION OF ENGINEERS, SRI LANKA

IESL Engineering Course

Part III Examination

308 POWER SYSTEMS II

Time Allowed: **3 hours** October 2013

Answer any **five** Questions. All Questions carry equal marks.

Q1

The layout and data relevant for a load flow analysis of a 132 kV power system is given in Fig. Q1.

a) Form the nodal admittance matrix for this system. [20]

b) Form the matrices that are necessary to perform a load flow study on this system using the fast decoupled load flow. [30]

c) Perform the first iteration of load flow. [30]

d) Why do the power system operators prefer to provide reactive power demand locally? [20]

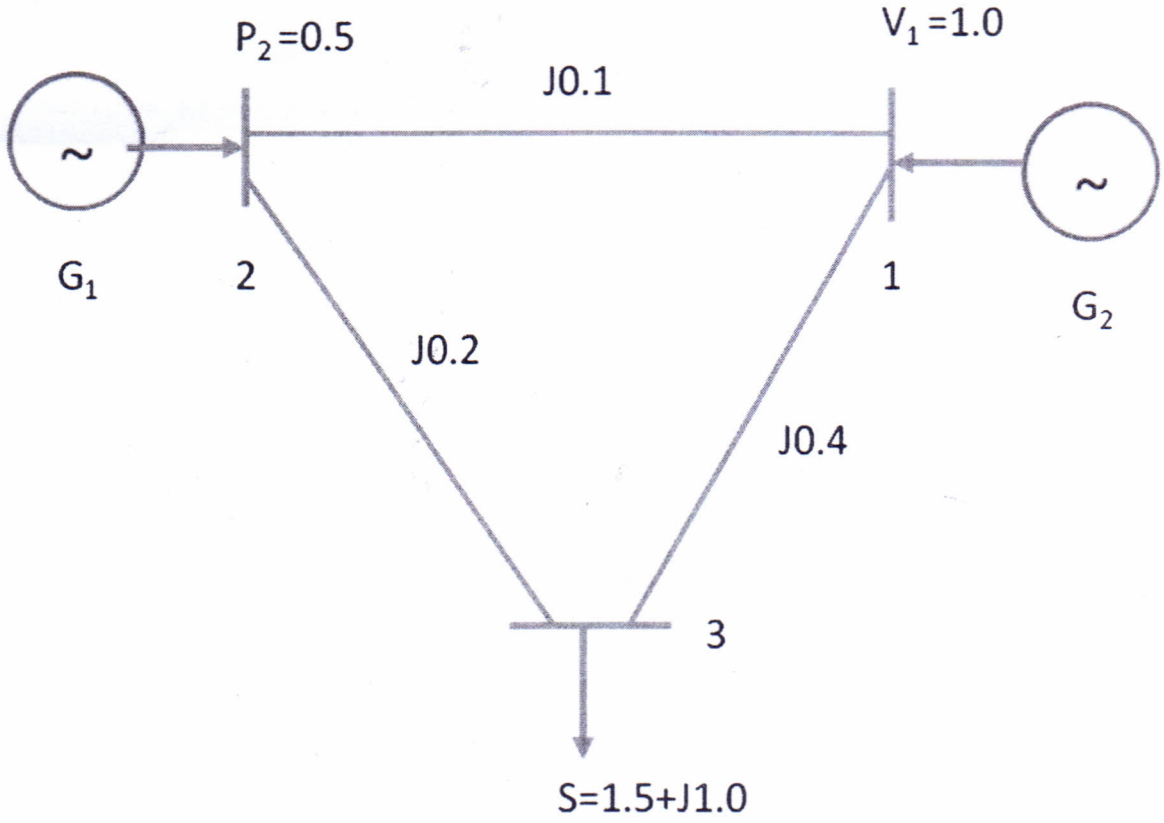

Figure Q1

Q2

Two synchronous generators A and B are rated at 200 MW and 300 MW respectively. For a load of 200 MW the generators operate at 50 Hz and are equally loaded. When the system load increases to 500 MW, the generators are fully loaded and the system frequency drops by 2.5%.

a) Calculate the droop characteristics of generators A and B. [30]

b) Find the maximum load the two generators jointly can take without violating frequency rules that are valid in Sri Lanka. [20]

c) Find the maximum load and the corresponding frequency at which generator B would produce no output and the total load would be supplied by generator A only. [20]

d) "In the Sri Lankan Power System tripping of a large power plant like Lakvijaya during off peak can lead to cascade tripping". Explain how and under what conditions this would happen. [20]

e) What remedial action would you propose to avoid such a cascade tripping event? [10]

Q3

The daily demand curve of Sri Lanka on an average day is estimated as given in the table below:

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

A mixture of power plants with total installed capacity of 3600 MW is available to meet this demand. However, the total capacity is not always available and the probability of the cumulative capacity availability is given below:

x in MW	complimentary cumulative probability, $P(C > x)$
$0 < x < 1800$	1.0 (approximate value)
$1800 < x < 3600$	$0.6 + 720/x$
$x = 3600$	0.8

a) Calculate the total energy demand per day. [10]

b) What is the LOLP with reference to a day? [20]

c) How many days will be there in a year in average on which the peak demand can't be met? [10]

d) What is the probability for the total available capacity to be x for $1800 < x < 3600$? [20]

e) What would be the average value of un-served Energy on a day? [40]

Q4

a) State five different busbar arrangements used in HV substations and give a sketch of each arrangement. [30]

b) State the advantages and disadvantages of two of the above arrangements commonly used in Sri Lanka. [20]

c) Under what conditions do we resort to Gas-Insulated Substations? [20]

d) The modern GIS widely use SF_6 as the dielectric. What properties of SF_6 make it so desirable? Also state undesirable properties of SF_6 if any. [30]

Q5

a) State the characteristics of power plants that are best suited to meet

i. Base load

ii. Intermediate load

iii. Peak load [10]

b) The cost functions of three thermal power plants are given below: Here, F_i denotes the cost of operation in Currency Units (CU) when serving a load P_i.

$$F_1 = 180 + 8.7P_1 + 0.0025P_1^2 \qquad 50 \le P_1 \le 270MW$$
$$F_2 = 140 + 9.0P_2 + 0.0026P_2^2 \qquad 50 \le P_2 \le 270MW$$
$$F_3 = 200 + 8.6P_3 + 0.0020P_3^2 \qquad 50 \le P_3 \le 270MW$$

Prepare a merit order list considering per MWh cost of each unit at its maximum possible load. [25]

c) How would you dispatch a load of 600 MW using merit order dispatch. [10]

d) Calculate the expected total cost per hour based on the cost in the merit order. Also calculate the actual cost and explain why the actual cost is larger than the expected cost. [25]

e) Repeat the dispatch using incremental cost method and also calculate the corresponding actual cost. Up to 1% overloading of any plant is permitted. [30]

Q6

a) Describe briefly the concept of transient stability in a power system [10]

b) State and describe the equal area criteria used to determine the transient stability in a power system. [20]

c) A 600 MVA synchronous generator produces 1.5 pu voltage behind a transient resistance (X_d') of 0.25 pu. The generator is connected to a busbar through a transformer having a reactance of 0.15 pu. This busbar is then connected to an infinite busbar operating at 1.0 pu voltage through a double circuit line having a reactance of 1.0 pu on each. All reactance are given on a base of 600 MVA.

Active power amounting to 420 MW is being delivered by the generator when a 3 phase fault occurs on one circuit half the distance from the infinite busbar end. The fault is cleared by opening the faulty circuit at both ends. Use equal area criterion to determine the critical clearing angle in order to maintain the transient stability of the generator. [70]

Q7

a) What is meant by "equivalent span" in sag-tension calculation? [20]

b) Develop an expression for the length of an "equivalent span" suitable for use in sag-tension calculations, given that the total length of section of line comprises of four spans of lengths l_1, l_2, l_3 and l_4. [30]

c) One span of an overhead High Tension (HT) transmission line is suspended between supports 350 m apart and at heights respectively of 32 m and 100m above a datum. The line is strung to a tension of 25 kN. If the conductor weighs 2.25 kg/m, determine the vertical component of the tension at the lower support (suitable approximations can be made). Take g as 9.8 m/s^2. [30]

d) A Low Tension (LT) line runs under the conductors of the above HT line between the two towers 50 m away from the first (32 m) HT tower. If the LT conductor runs 20 m above the datum, calculate the clearance between LT and HT conductors. [20]