Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.Tech (EE)/SEM-2/EDPM-202/2013

2013

POWER SYSTEM DYNAMICS

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer question No. 1 and any *four* from the rest.

1. Answer any *seven* of the following : $7 \times 2 = 14$

a) Choose the correct answer and explain. By using the method of equal area criterion, we get the information about

(a) Swing curves (b) Stability region

(c) relative stability (d) Absolute stability.

b) The study of steady state stability is concerned with the upper limit of machine loadings before losing synchronism when load is gradually increased. Discuss.

c) The transient stability limit is almost always lower than the steady state limit, but unlike the later, it may exhibit different values depending on the nature, location and magnitude of disturbance. Discuss.

d) Define 'Inertia constant (M)' and write the 'Swing Equation'.

e) A two pole, 50 Hz, 11 kV turbo-alternator has a rating of 100 MW, power factor 0.85 lagging. The rotor has a Moment of Inertia of a 10,000 kg-m^2. Calculate H and M.

f) A synchronous condenser (dynamic compensator) is nothing but synchronous motor running at no-load. Do you agree ? Clarify.

g) A long line with no-load, generates capacitive reactive power. Do you agree ? Clarify.

h) Voltage instability occurs when the system Z is such that, $dV/dZ = \infty$ or $dZ/dV = 0$. Application of this criterion gives value of Z_{cri}. Explain.

i) For a fault in the power system, the term critical clearing time is related to the transient stability limit. Explain.

j) Explain the equation K_{sg} X K_t is nearly equal to 1. Notations have their usual meanings.

2. a) What are the different types of Excitation Systems ? Explain with the functional block diagram, the elements of excitation system.

b) Explain Dynamic performance measures of Excitation System with reference to small-signal performance measures and large signal performance measures.

c) A generator is operating under steady-state condition with an E_{fd} of 2.598 pu and E_t = 1.0 pu. If it is equipped with a type AC4A excitation system represented by the block diagram of figure below, determine the value of V_{ref}.

The parameters of the excitation systems are the same as for the sample data provided with the figure below.

Sample data

Exciter and regulator :

K_A = 200.0 T_A = 0.04 T_C = 1.0 T_B = 12.0 V_{RMAX} = 5.64

V_{RMIN} = - 4.53 K_C = 0 V_{IMAX} = 1.0 V_{IMIN} = -1.0

Type AC4A exciter model

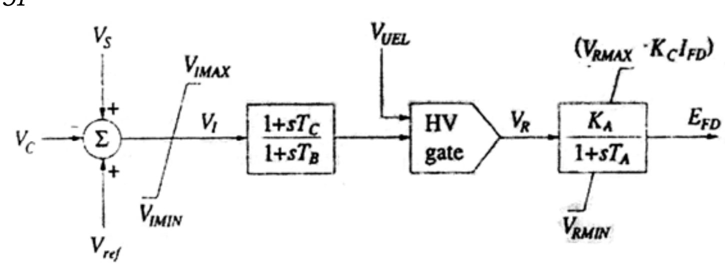

Figure : IEEE Type AC4A excitation system model.

3 + 3 + 8

3. Deduce Hydraulic Turbine Transfer Function and clearly mention the assumptions for the representation of the hydraulic turbine and water column in stability studies.

10 + 4

4. a) The transfer function of classical and non-ideal hydraulic turbine is given by

i) $$\frac{\Delta\bar{P}m}{\Delta\bar{G}} = \frac{1 - T\omega s}{1 + \frac{1}{2} T\omega s}$$ and

ii) $$\frac{\Delta\bar{P}m}{\Delta\bar{G}} = a_{23} \frac{1 + (a_{11} - a_{13} \frac{a_{21}}{a_{23}}) \ T\omega s}{1 + a_{11} T\omega s}$$

Represent a "non-minimum phase"-Explain. the notations have their usual meanings.

b) Illustrate the special characteristics of the transfer function by considering the response to a step change in the gate position of hydraulic turbine. 8 + 6

5. The data related to the turbine, penstock, and generator of a hydraulic power plant are as follows :

Generator rating = 140 MVA Turbine rating = 127.4 MW

Penstock length = 300 m Piping area = 11.15 m^2

Rated hydraulic head = 165 m

Water-flow rate at rated load = 85 m^3/s

Gate opening at rated load = 0.94 pu

Gate opening at no load = 0.06 pu

a) Calculate the following :

i) the velocity of water in the penstock,

ii) water starting time at full load.

b) Determine the classical transfer function of the turbine relating the change in power output to change in gate position at rated load.

c) Determine the non-linear model of the turbine, assuming an inelastic water column. Identify the values of the parameters and variables of the model at rated output. The turbine mechanical power/torque is to be expressed on a common MVA base of 100. 6 + 4 + 4

6. a) Explain and deduce the Static Load Models.

b) Explain Dynamic Load Models and state the dynamic aspects of load components that require consideration in stability studies.

c) Find the capacity of a static VAR compensator to be installed at a bus with ± 5% voltage fluctuation. The short circuit capacity is 5000 MVA. 5 + 5 + 4

7. a) Draw composite static and dynamic load model and explain.

b) Draw a simple model for thermostatically controlled loads and explain.

c) Draw a realistic model for thermostatically controlled loads and explain

d) Explain the following Criterion of Voltage Stability :

$\frac{dE}{dV}$ Criterion & $\frac{dz}{dv}$ Criterion 3 + 3 + 3 + 5

8. a) Explain voltage stability with HVDC links.

   b) How can you prevent voltage collapse ?

   c) A load bus is composed of induction motor where the nominal reactive power is 1 pu. The shunt compensation is less. Find the reactive power sensitivity at the bus with respect to change in voltage. 4 + 6 + 4