*Please attempt all questions:*

First Question (20 Marks)

Three generating units are operating in parallel at 50 Hz to supply a total load of 1000 MW. Unit No.1 with a rated output of 500 MW and 4% speed-droop characteristic, supplies 300 MW. Unit No.2 with a rated output of 600 MW and 5% speed-droop characteristic, supplies 300 MW. Unit No.3 with a rated output of 600 NW and 4% speed-droop characteristic, supplies the rest of the load. Assuming no control action would take place, determine;

a- The new load on each unit if the total load decreased to 800 MW and the value of the corresponding frequency.

b- The minimum and maximum loading level for the system before any control action would take place.

Second Question (15 Marks)

a- Drive the transfer function for the shown speed control mechanism of a generating unit, and then obtain the relation between ΔX_c & ΔX_E.

Hydraulic amplifier (speed control mechanism)
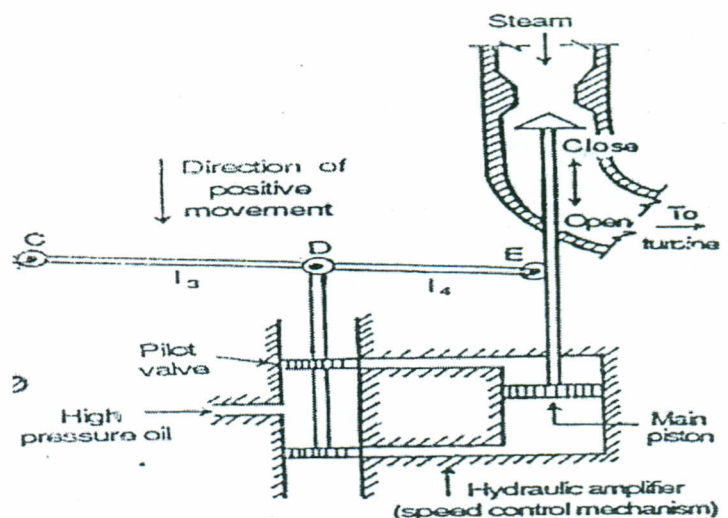
Third Question (15 Marks)

a- What are the factors affecting the active- and reactive-power flow in a transmission line connected between two buses?

b- A transmission line which has an inductive reactance of 30 Ω and negligible resistance is connected between two sources with voltages of 22 kV and 20 kV. If an active power flow 5 MW is transferred from the 22 kV bus side to the 20 kV bus side, determine;

(i)   The transmission line power angle.

(ii) The reactive power flow and reactive power loss in the line.

(iii) The load power-factor.

Fourth Question (15 Marks)

Four generating units are operating in parallel in a power station having ramp ratings as 20, 30, 8 and 12 MW/min. Their rating capacities are 120, 160, 180, and 100 MW, where the loading levels of the units are 106, 140, 156, and 89 MW respectively. Determine the minimum time required to distribute an increase in load of 60 MW among these generating units and the amount of change in load on each unit.

Fifth Question (15 Marks)

An alternator is feeding an infinite bus of voltage $|V|=1.0$ p.u. and is running over-excited with $|E|=1.03$, with an active output power of 0.5 p.u. Assume generator reactance $X_g=1.0$ p.u.

- a- If the input mechanical power is increased by 30%, find the change in the reactive power flow to the infinite bus.
- b- Also, if the field current is increased by 30%, find the change in the reactive power flow to the infinite bus.
- c- Comment on the results.

Sixth Question (20 Marks)

2- Draw and explain, in details, the schematic diagram and the block diagram for the Automatic Voltage Control of a generating unit , then,

a) Write the transfer function of each component, and that for the closed-loop system.

b) If the load change on a generating unit is a step input, i.e. $\Delta P_L (s) = \Delta P_L/ s$. Find the steady-state deviation in frequency by utilization of the final-value theorem $(\Delta w_{ss} = \lim s. \Delta \Omega (s))$.

With My Best Wishes   *Prof. Kamal Shebl*