Aalto-yliopisto
Teknillinen korkeakoulu

Exercise 6

Power systems

Question 1

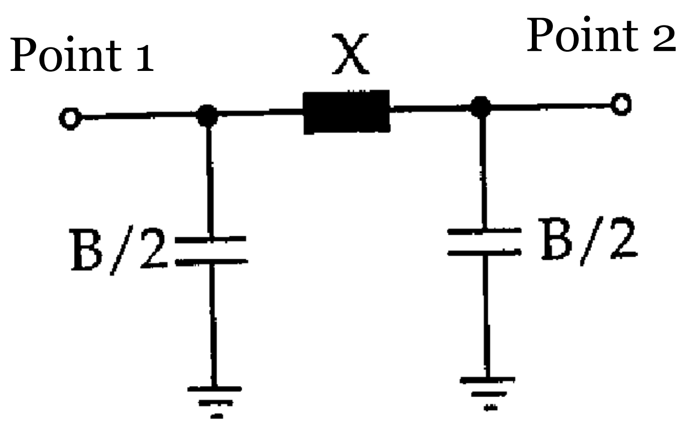
a) Derive the following equation
for the voltage drop over a transmission line

$$U_{loss} \approx I\,R \cdot \cos\varphi + I\,X \cdot \sin\varphi$$

b) Can this equation be applied in all situations?

c) Draw the phasor diagrams related to the equation
in cases where the reactive power is inductive and capacitive.

Question 2



$X = 168\ \Omega$
$B = 0{,}87\ \text{mS}$

10 MW of active power is transferred using a three-phase line shown in the picture.
Line-to-line voltages in the both ends of the line are 110 kV.
Calculate the power factor (cosφ) of the load.

Question 3

A turbine generator is delivering 20MW at 50Hz to a local load;
it is not connected to the grid.

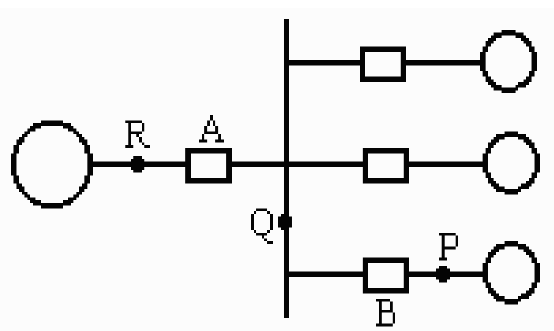
The load suddenly drops to 15MW;
and the turbine governor starts to close the steam valve after a delay of 0.5s.

The stored energy in the rotating parts is 80MJ at 3000rev/min. What is the generated frequency at the end of the 0.5s delay?

Question 4

A 625-kVA 2.4 kV generator with $X''_d = 0.20$ per unit is connected to a bus through a circuit breaker, as shown in the figure below. Connected through circuit breakers to the same bus are three synchronous motors rated 250 hp, 2.4 kV, 1.0 power factor, 90% efficiency, with $X''_d = 0.20$ per unit. The motors are operating at full load, unity power factor, and rated voltage, with the load equally divided among the machines.

For interrupting current, presume that transient reactance for the synchronous motors is 1.5 times the subtransient reactance. For the generator, apply the subtransient reactance.



(a) Draw the impedance diagram with the impedances marked in per unit on a base of 625 kVA, 2.4 kV.

(b) Find the symmetrical short-circuit current in amperes, which must be interrupted by breakers A and B for a three-phase fault at point Q. Simplify the calculations by neglecting the pre-fault current.

(c) Repeat part (b) for a three-phase fault at point P.