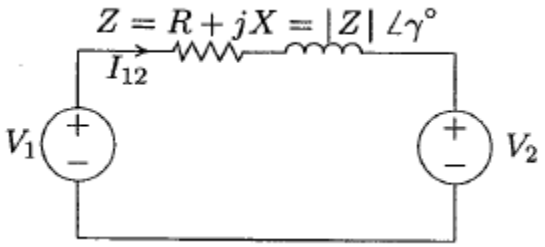
ER57 EXAMEN FINAL

18 janvier 2024 de 8h00 à 10h00 en salle P305 à Sevenans

The use of lecture notes is not allowed.

QUESTION 1 (4 MARKS)

Consider two ideal voltage sources connected by a line of impedance $Z = R + jX\ \Omega$, as shown in Figure. Assume, as is often the case in high-voltage systems, **that *R=0***. The current phasor $\boldsymbol{I}_{12}$ is positive if it goes from source 1 to source 2. Let the phasor voltages be $V_1 = |V_1|\angle\delta_1$, and $V_2 = |V_2|\angle\delta_2$.

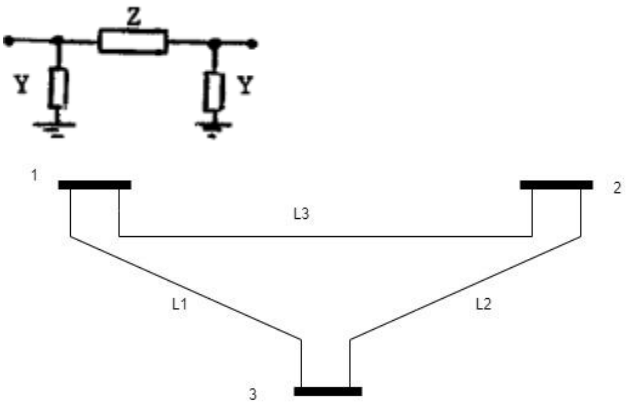


Compute

1) The active power at the sending end 1 (**1 mark**)
2) The reactive powers at the sending end 1 (**1 mark**)
3) The active power at the receiving end 2 (**1 mark**)
4) The reactive power at the receiving end 2 (**1 mark**)

QUESTION 2 (4 MARKS)

Consider the 3-bus system below, and assume all three lines as electrically medium length and each represented by the π-model .



To simplify consider that Y and Z have the same value for each line. Assume also that each node has an injected complex power given by:

$$S_1 = P_1 + jQ_1 \triangleq P_{G1} - P_{D1} + j(Q_{G1} - Q_{D1})$$
$$S_2 = P_2 + jQ_2 \triangleq P_{G2} - P_{D2} + j(Q_{G2} - Q_{D2})$$
$$S_3 = P_3 + jQ_3 \triangleq P_{G3} - P_{D3} + j(Q_{G3} - Q_{D3})$$

where $P_{G\mathrm{i}}$ ($Q_{G\mathrm{i}}$) is the active (reactive) generated power in bus i (i=1.2.3), and $P_{D\mathrm{i}}$ ($Q_{D\mathrm{i}}$) is the active (reactive) load power in bus i (i=1.2.3),

Write

1) The load flow equations of this system in complex form (**2 marks**)
2) The load flow equations of this system in real form, that is separating the real part and the imaginary part . (**2 marks**)

QUESTION 3 (4 MARKS)

Two generators rated 100MW and 300MW are operating in parallel. The droop characteristics of their governors are 4% and 5% respectively from no load to full load. Assuming that the governors are operating at 50 Hz at no load and that the speed changer does not change and there is no ALFC2 loop.

1) How would a load of 300MW be shared between them? (**2 marks**)
2) What will be the system frequency at this load? (**2 marks**)

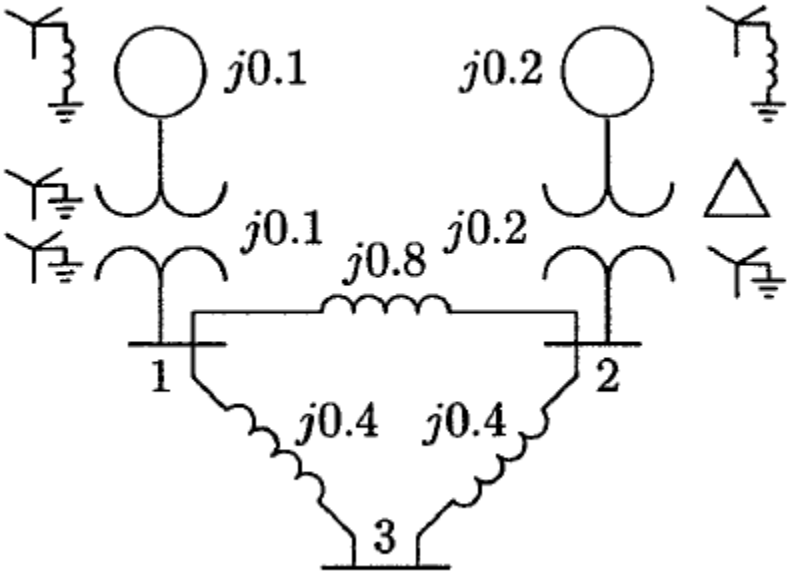
QUESTION 4 (4 MARKS)

Two generators are supplying power to a system. Their ratings are 60 and 600MW respectively. The frequency is 50 Hz and each generator is half-loaded. The system load increases by 220 MW and as a result the frequency drops to 49.5 Hz.

1) What must the individual regulations be if the two generators should increase their turbine powers in proportion to their ratings? (**2 marks**)
2) What conclusion can be drawn? (**2 marks**)

QUESTION 5 (4 MARKS)

Consider the one-line diagram of a simple three-bus power system, as shown in the figure below:



Each generator is represented by an emf behind the transient reactance. All impedances are expressed in per unit on a common 100 MVA base, and for simplicity, resistances are neglected. The following assumptions are made.

(i) Shunt capacitances are neglected, and the system is considered on no-load.
(ii) All generators are running at their rated voltage and rated frequency with their emfs in phase.

A balanced three-phase fault with a fault impedance $Z_f = 0.16$ per unit occurs **on bus 2.**

Determine:

- the fault current, (**2 marks**)
- the bus voltages, (**1 mark**)
- the line currents during the fault (**1 mark**).

The following formulas can be of help that transform a delta (or triangle connection) to a Wye (or star) connection of impedances:

$$Z_3 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$
$$Z_2 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$$
$$Z_1 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$$