ECE 4620/5620 [T_1 ; SP 2013]; NO: ☐

Name:

Prob 1: A power system has two fossil-fueled units on economic dispatch loop. The cost functions and the generation limits are given by:

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$$\begin{cases} C_1 = 400 + 10 P_{G1} + 8\times10^{-3} P_{G1}^2 \; ; & [C] = \$/hr \\ C_2 = 300 + 8 P_{G2} + 9\times10^{-3} P_{G2}^2 & [P_G] = MW \end{cases}$$

$$100^{MW} \le P_{G1} \le 600^{MW} \; ; \; 400^{MW} \le P_{G2} \le 1000^{MW}$$

Given $\lambda = 17.53$, find the optimal solutions P_{G1}^* and P_{G2}^* as well as the total demand P_D and the total cost.

Prob 2 Assume the power system below where all quantities are given in p.u.

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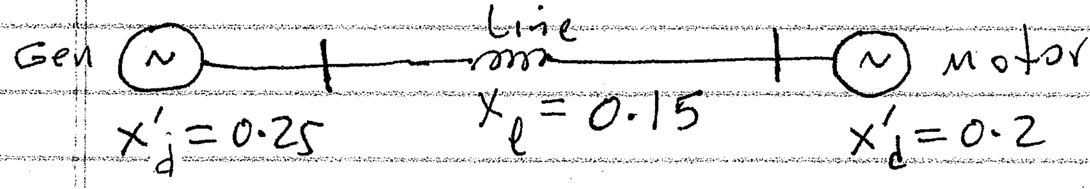

The motor is recieving an apparent power of 1.1 p.u at power factor 0.9 (lag) with terminal voltage of 1 p.u. Suddenly a 3-phase fault happens at generator terminal. Find the fault current during transient period

Prob 3: Given the source voltages are positive-sequence sets, find the fault current I_F as shown in system below.

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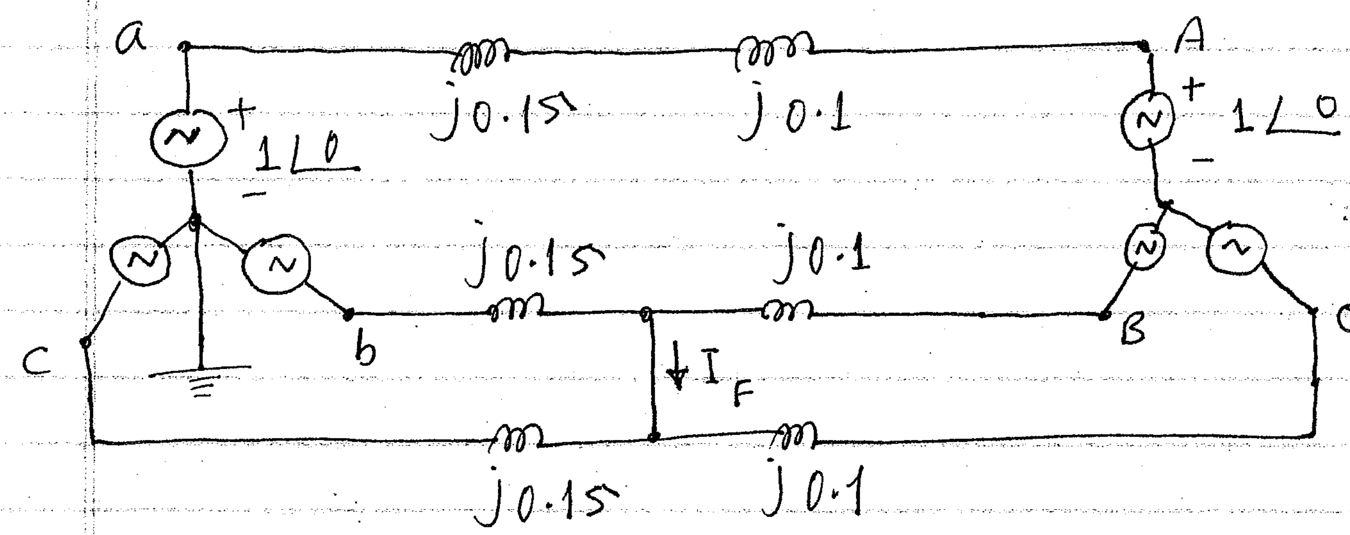

Prob 4: Consider the power system shown below with all quantities given in p.u.

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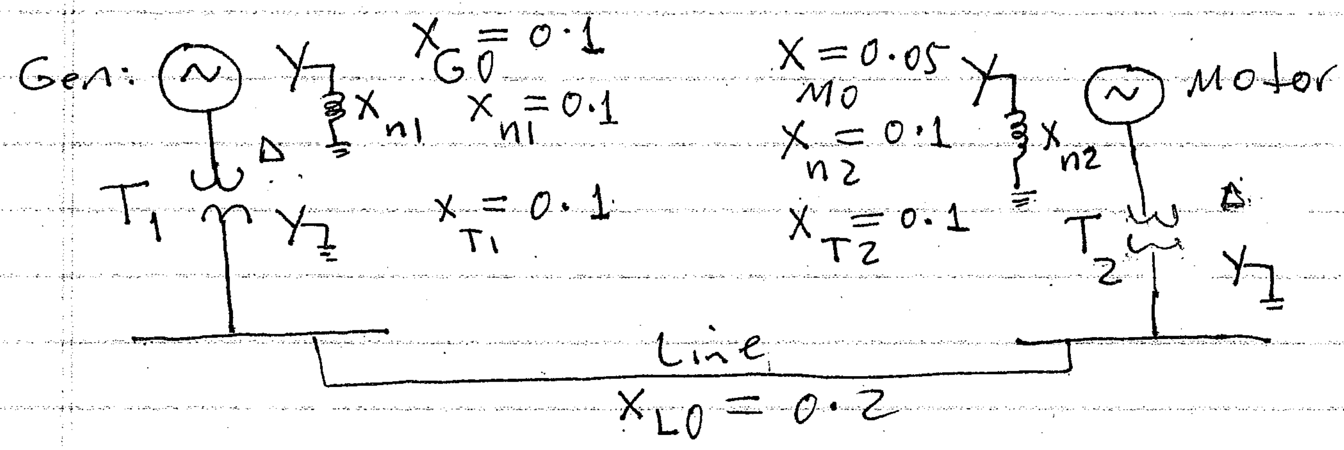


a) Draw the zero-sequence network for the system.

b) Find the zero-sequence impedance matrix for the system.

ECE 4620/5620 [T_1 ; SP 2013] ; Key

Prob 1: we are given $\lambda = 17.53$ and:

$$\begin{cases} C_1 = 400 + 10 P_{G_1} + 8\times10^{-3} P_{G_1}^2 \; ; & [c] = \$/hr \\ C_2 = 300 + 8 P_{G_2} + 9\times10^{-3} P_{G_2}^2 & [P] = MW \end{cases}$$

- $\lambda = \dfrac{dC_1}{dP_{G_1}} = 10 + 16\times10^{-3} P_{G_1} = 17.53$

$\Rightarrow \quad P_{G_1}^* = \dfrac{17.53 - 10}{16\times10^{-3}} = 470.63 \text{ MW}$ ✓

- $\lambda = \dfrac{dC_2}{dP_{G_2}} \;=\; 8 + 18\times10^{-3} P_{G_2} = 17.53$

$\Rightarrow \quad P_{G_2}^* = \dfrac{17.53 - 8}{18\times10^{-3}} = 529.44 \text{ MW}$ ✓

- $P_D = P_{G_1}^* + P_{G_2}^* = 470.63 + 529.44$

$= 1000 \text{ MW}$ ✓

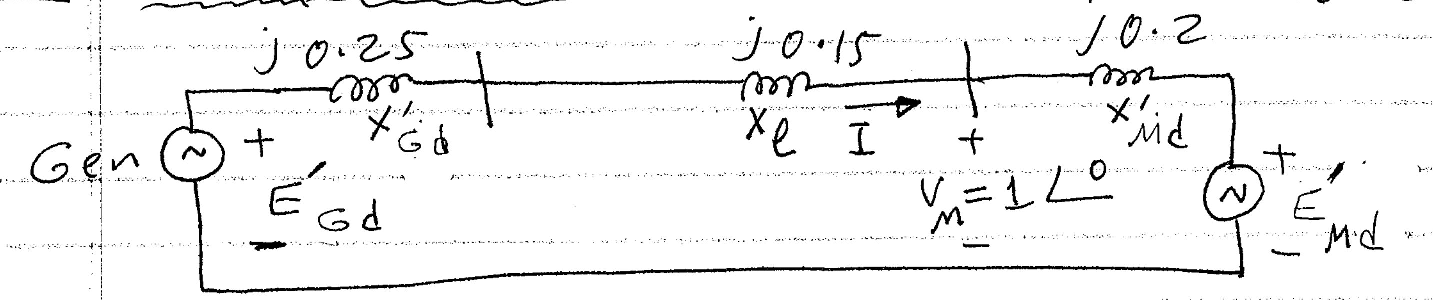
- $C_1 = 400 + 10 P_{G_1}^* + 8\times10^{-3} P_{G_1}^{*2} = \cdots = 6,878.24$ [\$/hr]

$C_2 = 300 + 8 P_{G_2}^* + 9\times10^{-3} P_{G_2}^{*2} = \cdots = 7,058.28$ [\$/hr]

now,

$C = C_1 + C_2 = \cdots = 13,936.52$ [\$/hr] ✓

Prob2: Before fault: Draw the circuit and find E'_{Gd}, E'_{Md}:



$$I = \left(\frac{S_M}{V_M}\right)^* = \left(\frac{1.1\,\angle \cos^{-1}(0.9)}{1\angle 0}\right)^* = \frac{1.1\angle -25.84^\circ}{1\angle 0}$$

$$= 1.1\angle -25.84^\circ$$

$$E'_{Gd} = V_M + j\,(0.25 + 0.15)\,I$$

$$= 1\angle 0 + j\,0.4\,\left(1.1\angle -24.84^\circ\right)$$

$$= 1 + j\,(0.4 - j\,0.18)$$

$$= 1 + j\,0.4 + 0.18 = 1.18 + j\,0.4$$

$$= 1.25\angle 18.73 \checkmark$$

$$E'_{Md} = V_M - j\,X'_{Md}\,I = 1 - j\,0.2\left(1.1\angle -25.84^\circ\right)$$

$$= 1 - j\,(0.22\angle -25.84^\circ)$$

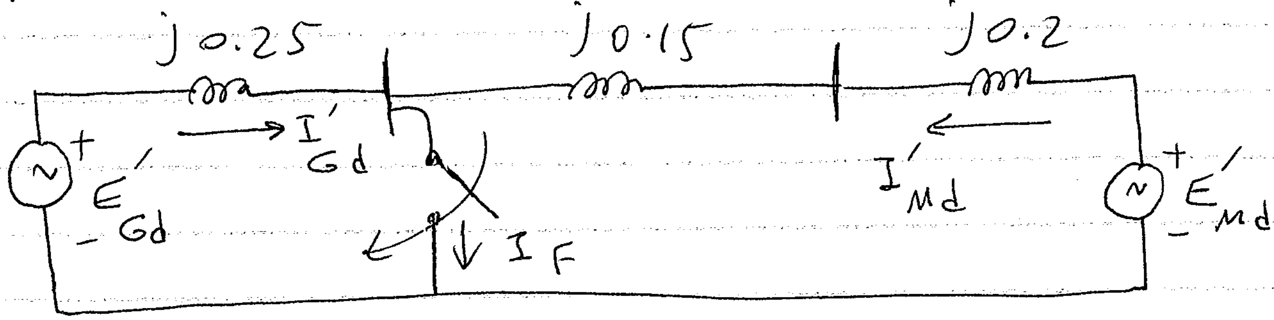
$$= 1 - j\,(0.2 - j\,0.1)$$

$$= 1 - j\,0.2 - 0.1 = 0.9 - j\,0.2$$

$$= 0.92\angle -12.53 \checkmark$$

Prob2 [Continued]

During the fault the circuit is as follows:



$$I_F = I'_{Gd} + I'_{Md}$$

$$= \frac{E'_{Gd}}{j0.25} + \frac{E'_{Md}}{j(0.15+0.2)}$$

$$= \frac{1.25 \angle 18.73}{j\,0.25} + \frac{0.92\angle -12.53}{j\,0.35}$$

$$= -j\left(\frac{1.25}{0.25}\angle 18.73\right) - j\left(\frac{0.92}{0.35}\angle -12.53\right)$$

$$= -j\left(5\angle 18.73\right) - j\left(2.63\angle -12.53\right)$$

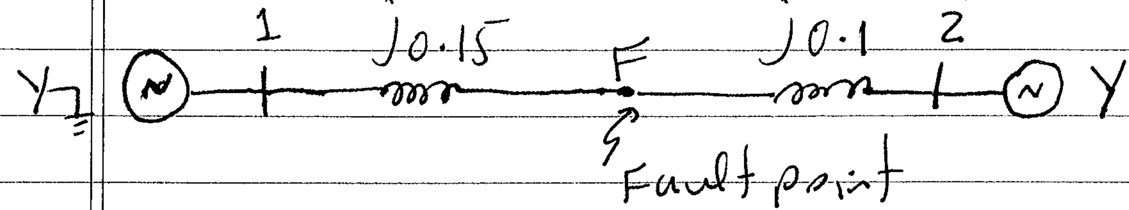
$$= -j\left(4.74 + j1.61\right) - j\left(2.57 - 0.57\right)$$

$$= -j4.74 + 1.61 - j2.57 + 0.57$$

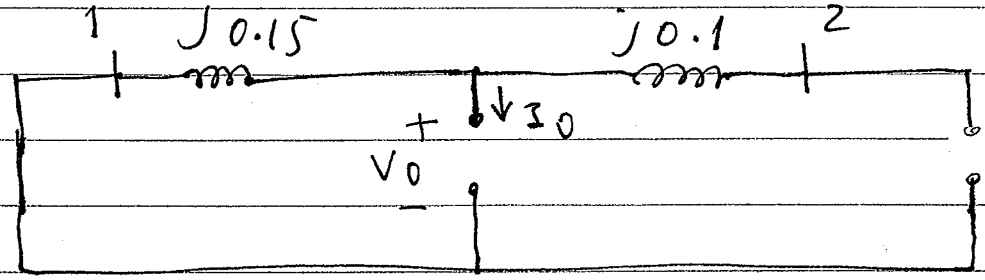
$$= 2.18 - j7.31$$

$$= 7.63 \angle -73.39^\circ \checkmark$$

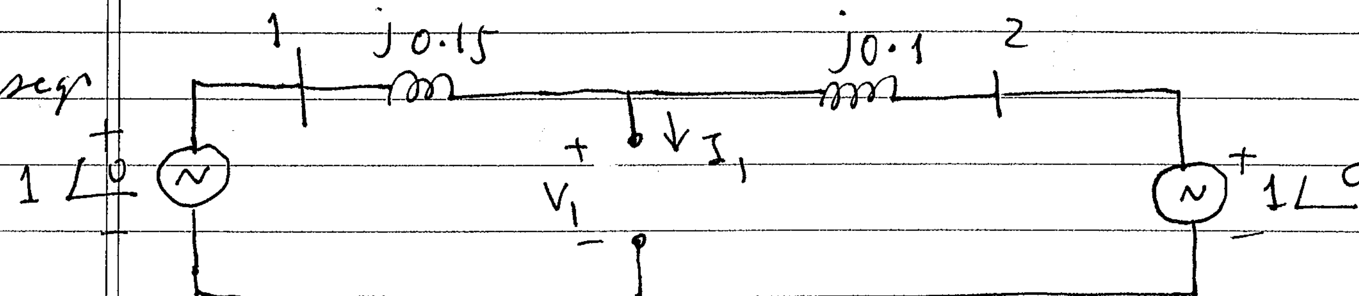
Prob 3: First we draw the single-line diagram and the sequence network:



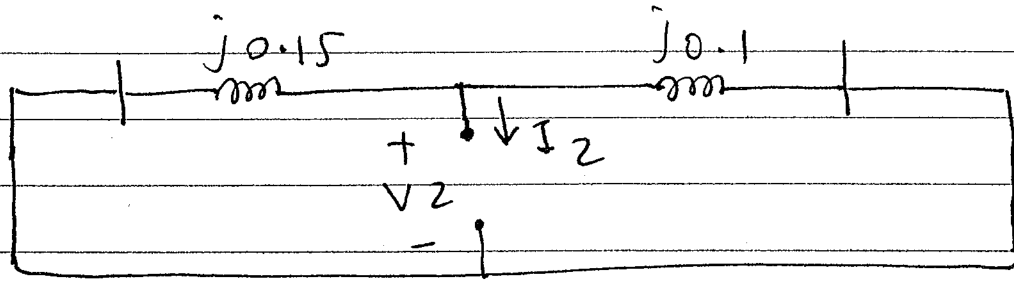
0-seq



pos-seq



neg-seq.



$\Longrightarrow$

$$Z_0 = j0.15$$

$$Z_1 = Z_2 = (j0.15) \parallel (j0.1)$$

$$= j\frac{(0.15)(0.1)}{(0.15)+(0.1)} = j\frac{0.015}{0.25}$$

$$= j0.06$$

Prob 3 [Continued]

This is a line-to-line fault and th
this fault we have:

$$I_0 = 0$$

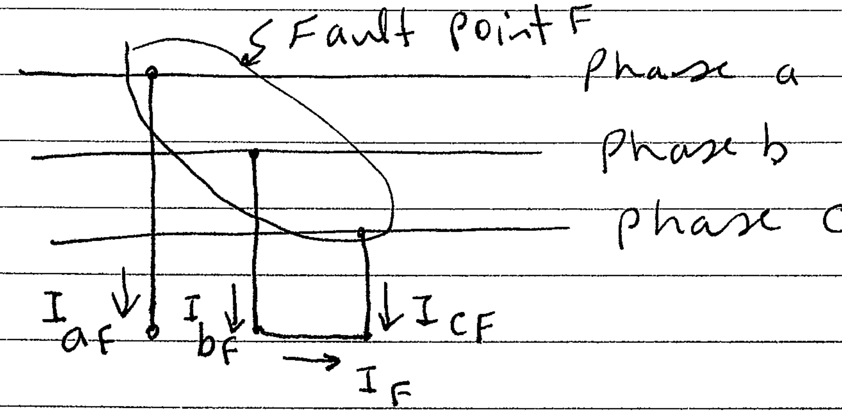
$$I_1 = -I_2 = \frac{V(0)}{Z_1 + Z_2 + Z_F} \; ; \; V(0) = 1\angle 0, \quad Z_F = 0$$

$$= \frac{1\angle 0}{j0.06 + j0.06 + 0} = -j\,8.33$$

$\Rightarrow$

$I_0 = 0, \quad I_1 = -j\,8.33 \; ; \; I_2 = +j\,8.33$

These are the sequence values of the fault current as defined below:



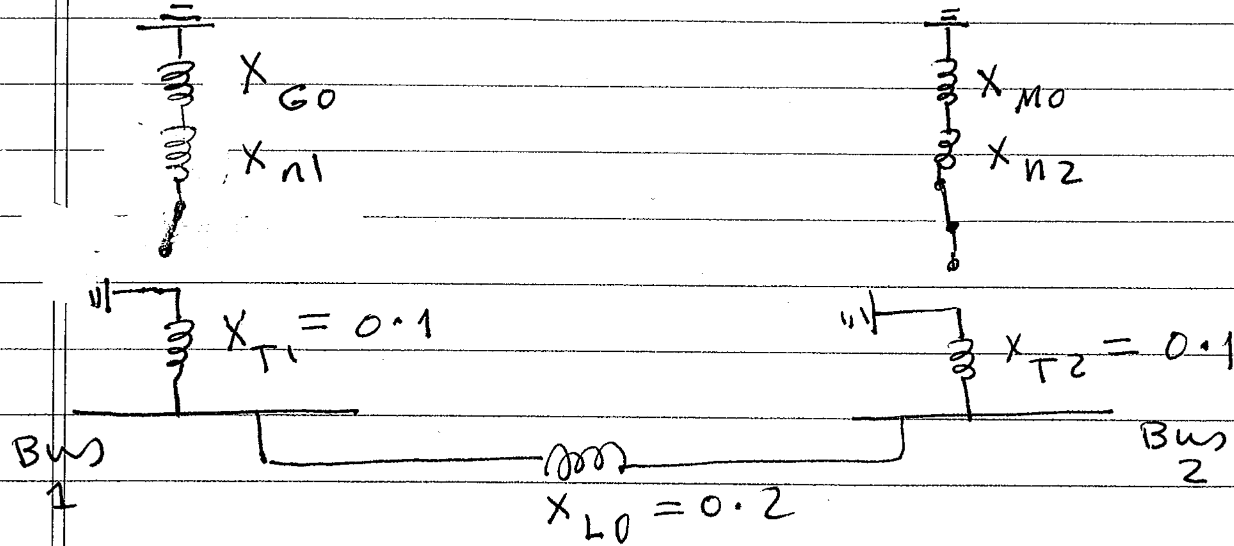
Comparing with the original circuit as given $I_F = I_{bF}$; so using sequence values we find I_{bF}:

$$I_F = I_{bF} = I_{0F} + a^2 I_{1F} + a I_{2F}$$

$$= 0 + (1\angle 120)^2(-j8.33) + (1\angle 120)(j\,8.33) = 14.43$$

Prob 4

a) Let's draw the zero-sequence circuit diagram:



b) $$Y_0 = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$$

where:

$$Y_{11} = \frac{1}{jX_{T1}} + \frac{1}{jX_{L0}} = \frac{1}{j0.1} + \frac{1}{j0.2} = -j10 - j5 = -j15$$

$$Y_{12} = Y_{21} = \frac{-1}{jX_{L0}} = \frac{-1}{j0.2} = +j5$$

$$Y_{22} = \frac{1}{jX_{T2}} + \frac{1}{jX_{L0}} = \dots = -j15$$

$$\Rightarrow Y_0 = j\begin{bmatrix} -15 & +5 \\ +5 & -15 \end{bmatrix}$$

$$Z_0 = Y_0^{-1} = \left(j\begin{bmatrix} -15 & 5 \\ 5 & -15 \end{bmatrix}\right)^{-1} = \dots = \left(j \times 10^{-2}\right)\begin{bmatrix} 7.5 & 2.5 \\ 2.5 & 7.5 \end{bmatrix}$$