

Due Mon Nov 12th, 9am

- 1) [20 pts] A 4-bus system is described by its positive sequence subtransient impedance and admittance matrices as given below.  $V_f = 1.05 \text{ pu}$

$$Z_{bus}^1 = j \begin{bmatrix} 0.1488 & 0.0651 & 0.0864 & 0.0978 \\ 0.0651 & 0.1554 & 0.0798 & 0.0967 \\ 0.0864 & 0.0798 & 0.1314 & 0.1058 \\ 0.0978 & 0.0967 & 0.1058 & 0.1566 \end{bmatrix} \quad Y_{bus}^1 = j \begin{bmatrix} -12.33 & 0.0 & 4.0 & 5.0 \\ 0.0 & -10.83 & 2.5 & 5.0 \\ 4.0 & 2.5 & -17.83 & 8.0 \\ 5.0 & 5.0 & 8.0 & -18.0 \end{bmatrix}$$

- a) A balanced  $3\phi$  fault occurs at bus 2. Calculate the fault current.

- b) Calculate the phasor voltages that exist during the fault at buses 1, 3 and 4.

- c) Calculate the phasor currents  $I_{12}$ ,  $I_{23}$  and  $I_{42}$  flowing between the faulted bus and the other system buses.

2) [20 pts] A 400-MVA 23-kV generator has the following parameters, given on the base of the generator:

$$\begin{aligned} X_d &= 1.85 \\ T_A &= 0.2\text{s} \end{aligned}$$

$$\begin{aligned} X_d' &= 0.33 \\ T_d' &= 0.8\text{s} \end{aligned}$$

$$\begin{aligned} X_d'' &= 0.25 \\ T_d'' &= 0.04\text{s} \end{aligned}$$

Assume that the generator is operating at no load and rated voltage when a  $3\phi$  fault occurs directly on the terminals.

a) Calculate the initial subtransient symmetrical RMS fault current  $I_{ac}(0)$  and the steady state fault current  $I(\infty)$ .

b) Write the expression for the maximum dc offset as a function of time.

c) Calculate the asymmetrical worst-case RMS short circuit current (in amps) that a 2-cycle breaker would have to interrupt.

- 3) [20 pts] The sequence bus impedance matrices (in per unit) for a 3-bus system are given below. Assume that the system has balanced positive sequence sources and that the prefault value of  $V_{AN}$  is  $1.05 \angle 0.0^\circ$ .

$$Z_{bus}^0 = j \begin{bmatrix} 0.15 & 0.08 & 0.0 \\ 0.08 & 0.20 & 0.0 \\ 0.0 & 0.0 & 0.30 \end{bmatrix}$$

$$Z_{bus}^1 = Z_{bus}^2 = j \begin{bmatrix} 0.12 & 0.08 & 0.04 \\ 0.08 & 0.12 & 0.06 \\ 0.04 & 0.06 & 0.08 \end{bmatrix}$$

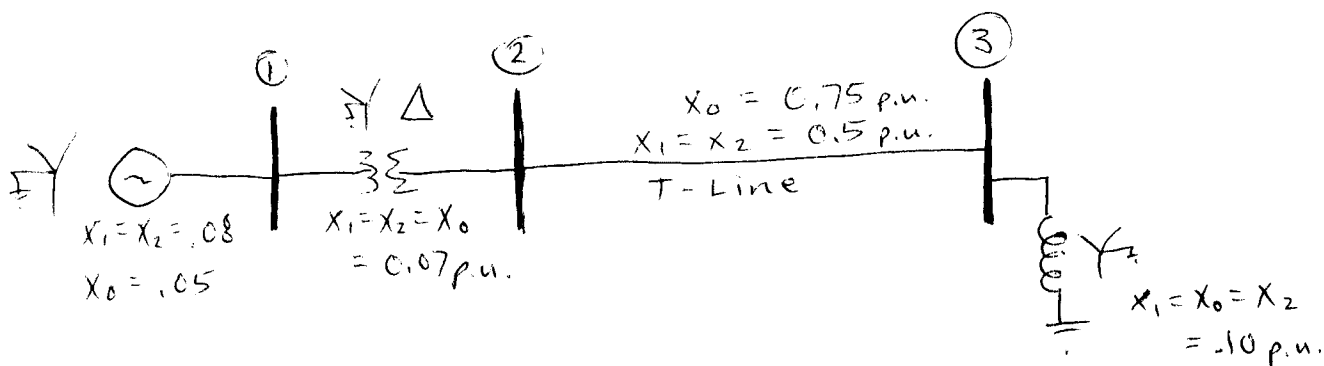
- a) Calculate the phasor values of  $I_{A1}$ ,  $I_{A2}$ ,  $I_{A0}$ , and  $I_C$  flowing in the fault for a L-L-G short circuit at bus 1.

- b) Calculate the phasor values of  $V_{A0}$ ,  $V_{A1}$ ,  $V_{A2}$  and  $V_A$  at bus 2 during the fault.

- c) Calculate the phasor value of  $V_A$  at bus 1 during the fault.

- 4) [20 pts] Answer **any four of the** of the following short concept/essay questions. Be sure to clearly indicate which one you do not want graded, or the first four will be graded. **Explain in your own words - explanations copied word-for-word from your textbook will not be given full credit.**
- a) [5 pts] Explain how you would correct network fault current flows to account for pre-fault load current for a L-G fault.
- b) [5 pts] How do you incorporate a fault impedance  $Z_F$  into the  $Z_0$ ,  $Z_1$ ,  $Z_2$  network connections for a L-L-G fault?
- c) [5 pts] Dry rocky soils have a higher resistivity than wet silty soils. Explain what effect this has (if any) on the a) positive sequence, b) negative sequence and c) zero sequence impedances of a transmission line.
- d) [5 pts] Give at least 3 good reasons/uses for performing fault study calculations.
- e) [5 pts] The conductor spacing of transmission lines increases with voltage. What effect does an increase in phase spacing have on the characteristic impedance of the line? Explain.

- 5) [20 pts] A L-L fault occurs between phases B & C at bus 2 of the network shown. Assume that the prefault voltage at bus 2 is 1.05 per unit. Assume that the voltage at the generator leads corresponding voltages on the transmission line by  $30^\circ$ .



- Draw the sequence impedance networks and connect for the fault given.
- Thevenize the sequence networks about bus 2, connect for fault, and label all sequence voltages and currents.
- Solve for  $I_{A0}$ ,  $I_{A1}$ ,  $I_{A2}$ , and  $I_C$  flowing in the fault.
- Solve for  $I_{A0}$ ,  $I_{A1}$ ,  $I_{A2}$ , and  $I_A$ ,  $I_B$ ,  $I_C$  flowing through bus 1 toward the fault.