Arab Academy for Science and Technology

Electrical and Computer Control Department

Power System II (EE 441) sheet (3)

1- A 60 Hz turbo-generator is rated 500 MVA, 22 kV. It is connected in Y and solidly grounded and is operating at rated voltage at no load. It is disconnected from the rest of the system. Its reactances are $X_d'' = X_1 = X_2 = 0.15$ and $X_0 = 0.05$ per unit. Find the ratio of subtransient line current for a single line to ground fault to the subtransient line current for a symmetrical three phase fault.

2- Determine the inductive reactance in problem 1 in ohms to be inserted to the neutral connection of the generator to limit the subtransient line current for a single line to ground fault to that for a three phase fault.

3- A generator rated 100 MVA, 20 kV has $X_d'' = X_1 = X_2 = 20\%$ and $X_0 = 5\%$. Its neutral is grounded through a reactor of 0.32Ω. The generator is operating at rated voltage without load and is disconnected from the system when a single line to ground fault occurs at its terminals. Find the subtransient current in the faulted phase.

4- The reactances of a generator rated 100 MVA, 20 kV are $X_d'' = X_1 = X_2 = 20\%$ and $X_0 = 5\%$. The generator is connected to a Δ-Y transformer rated 100 MVA, 20Δ-230Y kV, with a reactance of 10%. The neutral of the transformer is solidly grounded. The terminal voltage of the generator is 20kV when a single line to ground fault occurs on the open circuited, high voltage side of the transformer. Find the initial symmetrical rms current in all phases of the generator.

5- A group of synchronous motors is connected through a transformer to a 4.16kV bus at a remote location from the generating plants to a power system as shown in figure 1. The motors are rated 600V and operate at 89.5% efficiency when carrying a full load at unity power factor and rated voltage. The sum of their output rating is 6000 hp. The reactances in per unit of each motor based on its own input kilovoltampere rating are $X_d'' = X_1 = 0.2$ and $X_2 = 0.2$ and $X_0 = 0.04$ per unit each is grounded through a reactance of 0.02 per unit. The motors are connected to the 4.16kV bus through a transformer bank of single phase units, each of which is rated 2400/600 V, 2500kVA. The 600V windings are connected in Δ to the motors and the 2400V windings are connected in Y. The leakage reactance of each transformer is 10%. The power system which supplies the 4.16kV bus is represented by a generator rated 7500kVA, 4.16kV with reactances of $X_d'' = X_2 = 0.1$ per unit, $X_0 = 0.05$ per unit, and X_n from neutral to ground equal to 0.05 per unit.

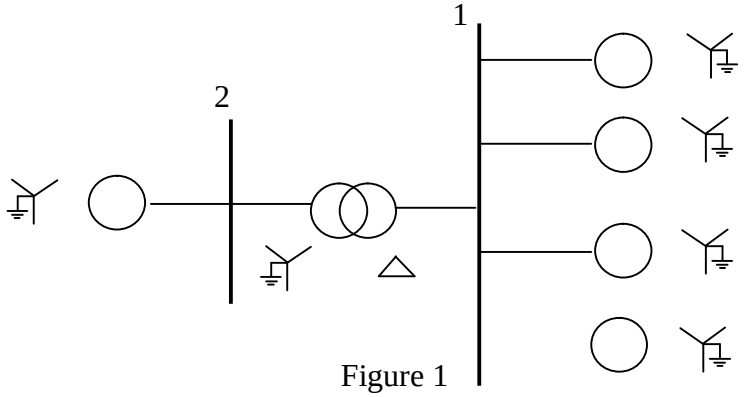

Figure 1

Solve for the subtransient current in a single line to ground fault first on bus 1 and then on bus 2 of the network shown below. Use the bus impedance matrix as:

$$Z_{bus} = \begin{bmatrix} j0.12 & j0.06 \\ j0.06 & j0.08 \end{bmatrix}$$

Also, find the voltages to neutral at bus 2 with the fault at bus 1.

6- Find the ratio of the subtransient line current for a line to line fault to the subtransient current for a symmetrical three phase fault on the generator of problem 1.

7- With the inductive reactance in ohms to be inserted in the neutral connection of the generator found in problem 2, find the ratios of the subtransient line currents for the following faults to the subtransient line currents for a three phase fault a) Single line to ground fault b) Line to line fault

8- A generator supplies a motor through a Y-Δ transformer. The generator is connected to the Y side of the transformer. A fault occurs between the motor terminals and the transformer. The symmetrical currents in the motor flowing towards the fault are:

$I_a^{(1)} = -0.8 - j2.6$ per unit

$I_a^{(2)} = -j2$ per unit

$I_a^{(0)} = -j3$ per unit

From the transformer towards the fault:

$I_a^{(1)} = 0.8 - j0.4$ per unit

$I_a^{(2)} = -j1$ per unit

$I_a^{(0)} = 0$ per unit

Assume that $X_d'' = X_1 = X_2$ for both the motor and the generator. Describe the type pf fault. Find also: a) the pre-fault current, if any, in phase 'a'

b) The subtransient fault current in per unit

c) The subtransient current in each phase of the generator in per unit

9- Each of the machines connected to the two high voltage buses shown in figure 2 below is rated 100MVA, 20kV with reactances of $X_d'' = X_1 = X_2$=20% and $X_o = 4\%$. Each three phase transformer is rated 100MVA, 345Y/20Δ kV, with leakage reactance of 8%. On the base of 100MVA, 345 kV the reactances of the transmission line are $X_1 = X_2$=15% and $X_o = 50\%$. Find the 2x2 bus impedance matrix for each of the three sequence networks. If no pre-fault current is flowing in the network, find the subtransient current to ground for a double line to ground fault on lines B and C at bus 1. Repeat for a fault at bus 2. When the fault is at bus 2, determine the current in phase b of machine 2 if the lines are named so that $V_A^{(1)}$ leads $V_a^{(1)}$ by 30º. If the phases are named so that $I_a^{(1)}$ leads $I_A^{(1)}$ by 30º, what letter (a,b or c) would identify the phase of machine 2 which would carry the current found for phase 'b' above?

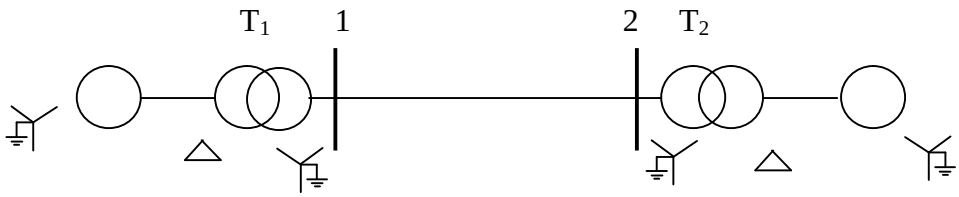

Figure 2

10- Two generator G_1 and G_2 are connected, respectively, through transformers T_1 and T_2 to a high voltage bus which supplies a transmission line. The line is open at the far end at which F a fault occurs. The pre-fault voltage at point F is 515 kV. Apparatus ratings and reactances are:

G_1 1000MVA, 20kV, X_s=100% $X_d'' = X_1 = X_2$=10% $X_o = 5\%$

G_2 800MVA, 22kV, X_s=120% $X_d'' = X_1 = X_2$=15% $X_o = 8\%$

T_1 1000MVA, 500Y/22Δ kV, $X = 17.5\%$

T_2 800MVA, 500Y/22Y kV, $X = 16\%$

Line X_1=15%, $X_o = 40\%$ on a base of 1500MVA, 500kV.

The neutral of G_1 is grounded through a reactance of 0.04Ω. The neutral of G_2 is not grounded. Neutrals of all transformers are solidly grounded. Work on a base of 1000MVA, 500kV in the transmission line. Neglect pre-fault current and find subtransient current

(a) in phase c of G_1 for a three phase fault at F

(b) in phase 'b' at F for a line to line fault on lines B and C

(c) in phase 'a' at F for a line to ground fault on line A

(d) in phase 'c' of G_2 for a line to ground fault on line A.

Assume $V_A^{(1)}$ leads $V_a^{(1)}$ by 30° in T_1.