1997

EE740

1 - 10
2 - 10
3 - 10
4 - 20
5 - 20
6 - 30

100

Name---------------

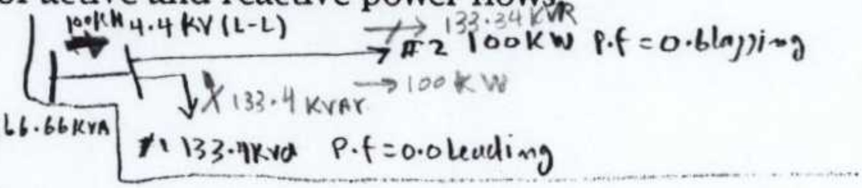
pledge "No aid given, received, or observed"

Department of Electrical Engineering

The Ohio State University

10

Problem 1. A ~~there~~ three phase distribution feeder has two loads : Load#1 is rated 133.4 kva with power factor of 0.0 leading. Load #2 is rated 100 kW with power factor of 0.6 lagging. Both loads are connected to the same load bus. If the load voltage is to be maintained at 4.4 kV(line value), compute the power factor at the load bus and the direction of active and reactive power flows.



$P = S\cos\theta$

$S = \frac{P}{\cos\theta} = \frac{100}{.6} = 166.66\,KVA$

$S = 166.66\angle 53.13\ KVA$

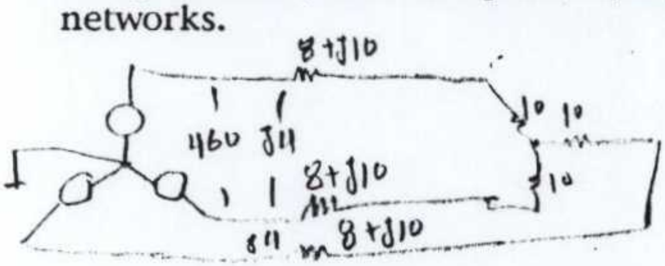
$= 100kW + j133.34$

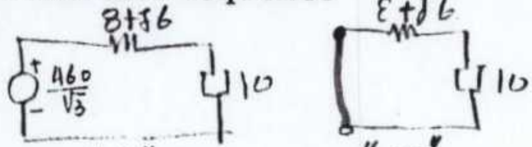
$S_2 = 133.34\angle -90 = 0 - j133.34$

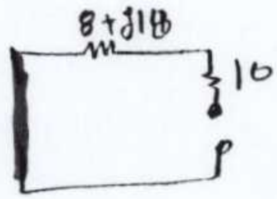
$S_{Total} = 100kW + j133.34 - j133.34 = 100\,kW \qquad P.f = 1$

10

Problem 2. A balanced wye connected generator rated 460 volts (line Value) is supplying a balanced wye connected resistive load of 10 ohms through a balanced transmission line with Zs = 8 +j10, Zab=Zbc=Zca=Zm= j4 (ohms). If the generator is grounded and load is not grounded , draw the positive, negative and zero sequence networks.







$Z_0 = Z_s + 2Z_m = 8 + j18$

$Z_1 = Z_s - Z_m = 8 + j10 - j4$

$Z_2 = Z_s - Z_m = 8 + j6$

10

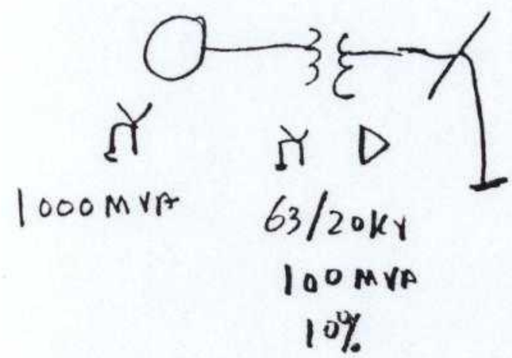
Problem 3 Same as problem 2, but both the generator and loads are grounded. Compute the symmetrical components of currents.

$I_1 = \frac{265.84\angle 0}{18+j6} = \frac{265.84\angle 0}{18\angle 18.4} = 14\angle -18.4^{\circ}$

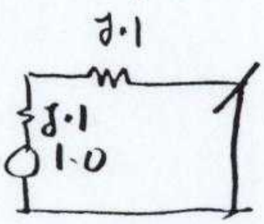
$I_2 = 0 \qquad I_0 = 0$

20

Problem 4. A three phase transformer rated 63 kV (wye connected and grounded)/20 kV(delta connected) ,100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. Assume a balanced three phase fault on 20 kV side while the 63 kV side is supplied from the power system at the rated voltage. Compute the short circuit capacity of 20 kV bus.



$$SCC_{p.u} = \frac{1000}{100} = 10 \qquad X_{th} = \frac{1}{10} = .1$$



$$I_f = \frac{1}{j.2} = 5 \text{ p.u}$$

$$S.C.C._{p.u} = 5 \text{ p.u}$$

$$S.C.C_{MVA} = 5 \times 100 = 500 \text{ MVA}$$

30

Problem 1. Consider the power system given below. Assume the following cases: Case 1): two phases are short circuited at bus 2 and then connected to ground. Case 2): one phase connected to ground at the mid section of 2o ohm transmission line between bus 6 and bus 7. Case 3): three phases are short circuited at bus 5 and then connected to ground. Determine whether the ground current will flow by indicating "yes" or "no" in the Table given below.

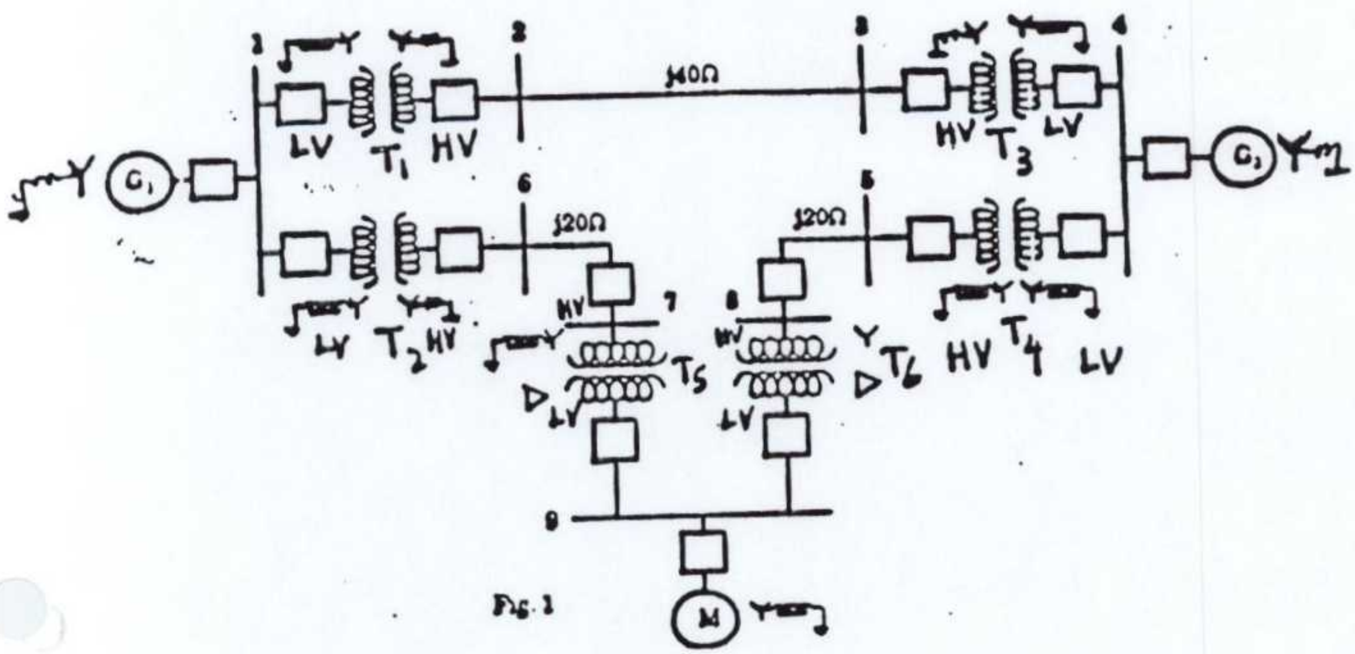


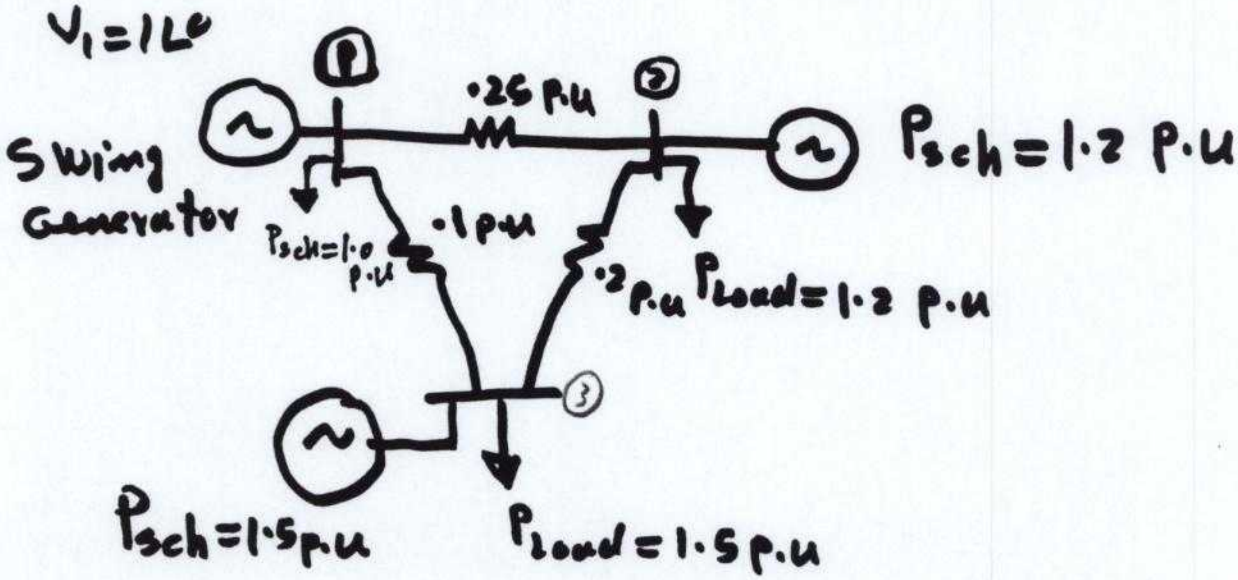
Fig. 1

Location	Case1	Case 2	Case 3
Ground reactance of trans. T3 o LV side	yes	yes	NO
Ground reactance of of generator G1	Yes	yes	NO
Ground reactance of motor M	NO	NO	NO
Ground reactance of generator G2	yes	Yes	NO
Ground reactance of trans.T4 on HV side	NO	NO	NO

Problem 4: A three phase transformer rated 63 kV (grounded wye) /20 kV(delta) ,100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. Assume a balanced three phase fault on 20 kV side while the 63 kV side is supplied from the power system at the rated voltage. Compute the short circuit capacity of 20 kV bus.

20

Problem 5. for the power system given below:



1) Compute Ybus model
2) compute Jacobian matrix
3) compute ΔP_2 and ΔP_3. Use one iteration only
4) Compute transmission line Losses.
5) compute the swing generator power supplied to the network.

$$Y_{BUS} = \begin{bmatrix} 14 & -4 & -10 \\ -4 & 9 & -5 \\ -10 & -5 & 15 \end{bmatrix} \qquad I_{BUS} = Y_{BUS} V_{BUS}$$

$V_1 = 1\angle 0$

$0 = V_2 I_2^*$ $\qquad I_2^* = 0 \qquad V_2 = 1\angle 0$

$0 = V_3 I_3^*$ $\qquad I_3 = 0 \qquad V_3 = 1\angle 0$

$\Delta P_2 = 0$

$$J = \begin{bmatrix} 9 & -5 \\ -5 & 15 \end{bmatrix}$$

$\Delta P_3 = 0$

$P_1 = 1.0$ p.u.

EE740

Final

Name---------------

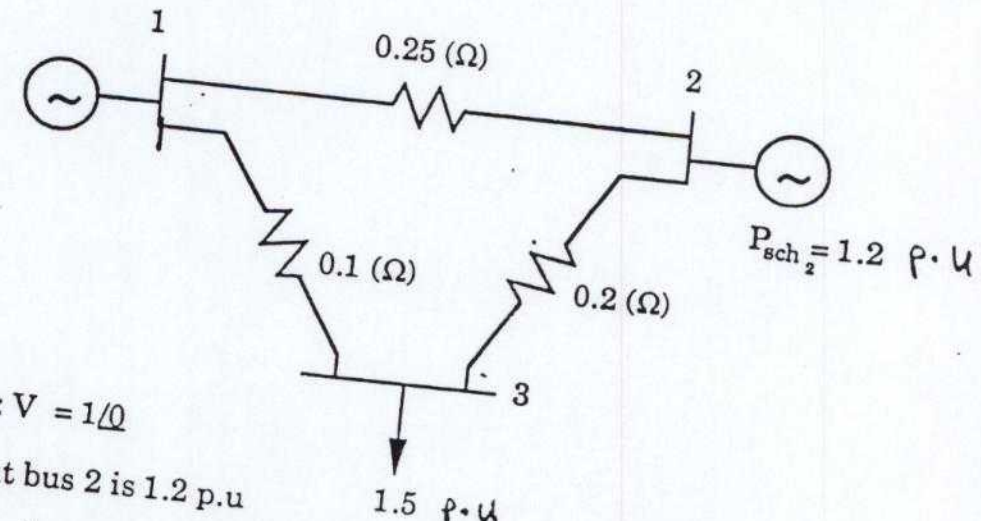
pledge "No aid given, received, or observed"

Department of Electrical Engineering
The Ohio State University

Fall 2000

Problem 7

EE740



Given:

- Bus 1 is slack bus: $V = 1\angle 0$
- Scheduled power at bus 2 is 1.2 p.u
- Schedule Load at Bus 3 is 1.5 p.u

Compute:

1) Y Bus model
2) Bus voltages using Gauss-Seidel Method
3) Power Mismatch at bus 2 and bus 3
4) Power supplied by the swing bus
5) Power Loss of transmission lines.

Problem 3. A three phase transformer rated 138 kV (grounded wye) /13.8 kV(grounded wye),100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. The power system bus voltage is 138 kV. The 13.8 kV side of transformer is fully loaded with a power factor of 0.0 lagging at rated voltage. Compute the fault current for a single line to ground fault at 13.8 kV bus for the following conditions: a) if the load is connected as a grounded wye . b) if the load is connected as an ungrounded wye . Assume that the impedance of positive, negative and zero sequence networks are equal.

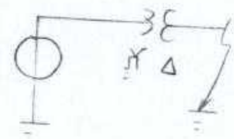
FINAL 1999

Problem 1. A three phase transformer rated 63 kV (grounded wye) /20 kV(delta),100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. Assume a balanced three phase fault on 20 kV side while the 63 kV side is supplied from the power system at the rated voltage. Compute the short circuit capacity of 20 kV bus.

Choose base values as

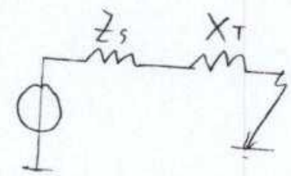
$S_b = 100\ MVA$

$V_{b.H} = 63\ KV \quad V_{b.L} = 20\ KV$



So the short circuit capacity of the system is

$SCC = \frac{1000}{100} = 10\ p.u.$



The Impedance of the system is

$Z_s = \frac{1}{S_{cc}} = 0.1\ p.u.$

The reactance of the transformer is

$X_T = 0.1\ p.u$

when a 3ϕ short occurs at low voltage side of trasformer

$Z_{eq} = Z_s + X_T = 0.1 + 0.1 = 0.2$

So the short circuit capacity is

$SCC_{20KV} = \frac{1}{Z_{eq}} = 5\ p.u$

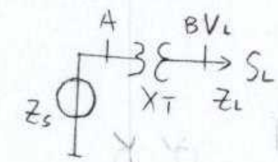
or $SCC_{20KV} = 5 \times 100 = 500\ MVA$

Problem 2. A three phase transformer rated 138 kV (grounded wye) /13.8 kV(grounded wye),100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. The power system bus voltage is 138 kV. The 13.8 kV side of transformer is fully loaded with a power factor of 0.0 lagging at rated voltage. Compute the fault current for a single line to ground fault at 13.8 kV bus for the following conditions: a) if the load is connected as a grounded wye . b) if the load is connected as an ungrounded wye . Assume that the impedance of positive, negative and zero sequence networks are equal.

Choose base values as

$S_b = 100\,MVA$

$V_{b,H} = 138\,kV$, $V_{b,L} = 13.8\,kV$

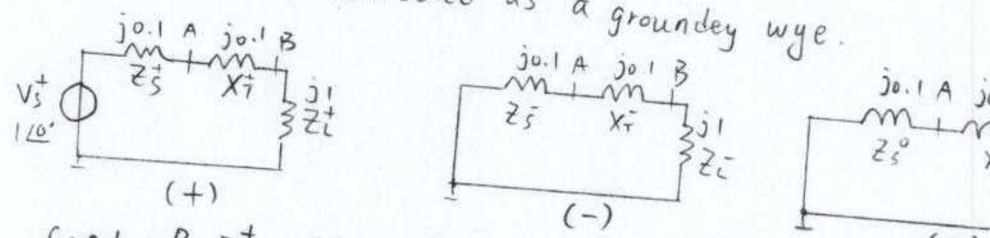


System impedance $Z_S = \frac{1}{SCC} = \frac{1}{\frac{1000}{100}} = 0.1\ pu$

transformer impedance $X_T = 0.1$ p.u.

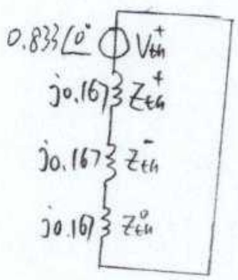
Load impedance $Z_L = \frac{|V_L^2|}{S_L^*} = \frac{1}{(1\angle 90^\circ)^*} = j1$ p.u.

a) the load is connected as a groundey wye.



for bus B, $Z_{th}^+ = Z_{th}^- = Z_{th}^0 = j0.2 // j1 = j0.167$ P.u

$V_{th}^+ = V_s^+ \frac{j1}{j1.2} = 0.833\angle 0^\circ$ pu



$I^+ = I^- = I^0 = \frac{V_{th}^+}{Z_{th}^+ + Z_{th}^- + Z_{th}^0} = \frac{0.833\angle 0^\circ}{3 \times j0.167} = -j1.67$ P.U.

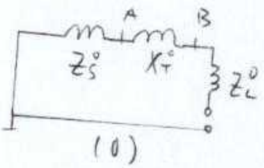
So $\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I^+ \\ I^- \\ I^0 \end{bmatrix} = \begin{bmatrix} -j5 \\ 0 \\ 0 \end{bmatrix}$ pu

$I_a = -j5 \times \frac{100 \times 10^6}{13.8 \times 10^3} = -j36.23 \times 10^3 A = -j36.23\,KA$

$I_b = I_c = 0$

b) the load is connected as an ungrounded wye.

the positive and negative sequence network are the same as in (a)



$Z_{th}^0 = Z_s^0 + X_T^0 = j0.2$

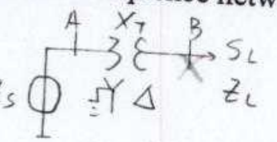
$I^+ = I^- = I^0 = \frac{0.833\angle 0^\circ}{j0.167 + j0.167 + j0.2} = -j1.56$ P.u

So $I_a = I^+ + I^- + I^0 = -j4.68$ pu $= -j33.91$ KA

$I_b = I_c = 0$

Problem 3 A three phase transformer rated 138 kV (grounded wye) /13.8 kV(delta),100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. The power system bus voltage is 138 kV. The 13.8 kV side of transformer is fully loaded with a power factor of 0.0 leading at rated voltage. Compute the fault current for a single line to ground fault at 13.8 kV bus for the following conditions: a) if the load is wye connected and grounded b) if the load is delta connected. Assume that the impedance of positive, negative and zero sequence networks are equal.

Choose $S_b = 100\,MVA$



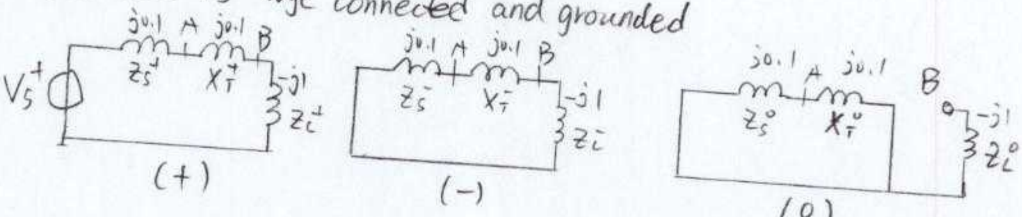
$V_{b.A} = 138\,kV \quad V_{b.B} = 13.8\,kV$

$$Z_S = \frac{1}{S_{CC}} = \frac{1}{\frac{1000}{100}} = 0.1\ p.u$$

$$X_T = 0.1$$

$$Z_L = \frac{|V_L|^2}{S_L^*} = -j1\ p.u$$

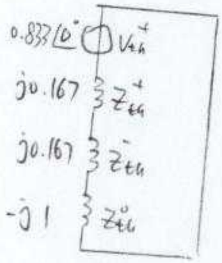
a) the load is wye connected and grounded



for bus B, $Z_{th}^+ = Z_{th}^- = j0.2 // j1 = j0.167\ p.u.$

$$Z_{th}^0 = Z_L^0 = -j1$$

$$V_{th}^+ = V_S^+ \times \frac{j1}{j1.2} = 0.833\angle 0^\circ\ p.u$$



$$I^+ = I^- = I^0 = \frac{V_{th}^+}{Z_{th}^+ + Z_{th}^- + Z_{th}^0} = \frac{0.833\angle 0^\circ}{j0.167 + j0.167 - j1} = +j1.25\ p.u$$

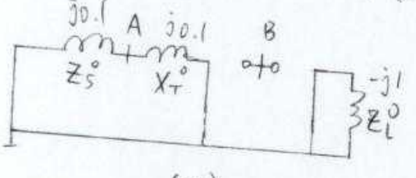
$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I^+ \\ I^- \\ I^0 \end{bmatrix} = \begin{bmatrix} +j3.75 \\ 0 \\ 0 \end{bmatrix}\ P.U$$

$$I_a = j3.75 \times \frac{100 \times 10^6}{13.8 \times 10^3} = j27.17\ KA$$

$$I_b = I_c = 0$$

b) the load is delta connected

the (+) and (−) sequence are the same as in a)



$$Z_{th}^0 = \infty$$

$$\text{So}\quad I^+ = I^- = I^0 = \frac{V_{th}^+}{Z_{th}^+ + Z_{th}^- + Z_{th}^0} = 0$$

$$I_a = I_b = I_c = 0$$

Problem 4 A transformer bank is composed of three single- phase transformers supplying a three-phase load consisting of
three identical 100 Ohm reactors. Each single transformer,
rated at 100 MVA ,138 kV/13.8 kV has a leakage reactance of 12% .The loads are connected in delta through a transmission line with .1+j.01 Ohm impedance.
Assume transformers are connected in wye/delta. Perform the following:
A)Compute the single -- phase equivalent circuit .
B)Compute per unit equivalent circuit for a base of 100MVA and a voltage base of 13.8kV.

A) for transformer connected in Y/Δ

$V_H = \sqrt{3} \times 138 = 239$ kV

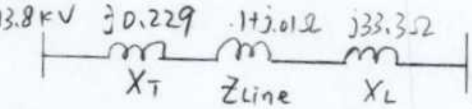
$V_L = 13.8$ kV

from LV side, $X_T = 0.12 \times \frac{(13.8 \times 10^3)^2}{100 \times 10^6} = 0.229\ \Omega$

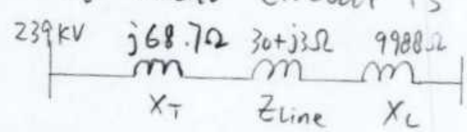
the Y equivalent reactance of the Load is

$X_L = \frac{100}{3} = 33.3\Omega$

So the equivalent circuit for LV side is



from HV side, the equivalent Circuit is



$X_T = 0.229 \times \frac{239^2}{13.8^2} = 68.7\Omega$

$Z_{Line} = (.1 + j.01) \times \frac{239^2}{13.8^2} = 30 + j3\Omega$

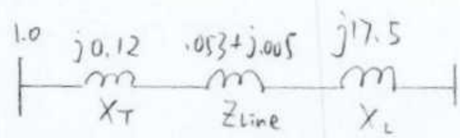
$X_L = 33.3 \times \frac{239^2}{13.8^2} = 9988\ \Omega$

B) $S_b = 100$ MVA, $V_b = 13.8$ kV $\quad Z_b = \frac{V_b^2}{S_b} = \frac{(13.8 \times 10^3)^2}{100 \times 10^6} = 1.9044$

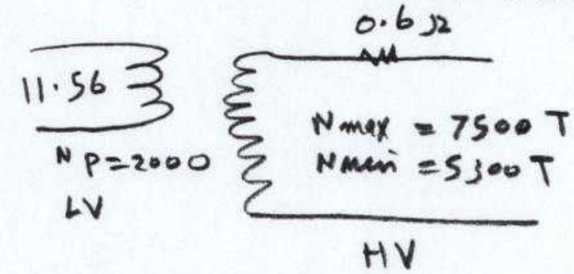
$X_T = 0.12$ p.u

$Z_{Line} = \frac{.1 + j.01}{1.9044} = .053 + j.005$ p.u.

$X_L = \frac{33.3}{1.9044} = 17.5$ p.u.



Problem 1. A single-phase tap changing transformer has 2000 turns on the low voltage side and variable number of turns on the high voltage side(N HV(max)=7500 turns, N HV(min)=5300 turns). The transformer is connected to a power system with the low voltage of 11.56 kV and the high voltage of 36.4 kV. The transformer is rated at 45 MVA and the short circuit reactance referred to the high voltage side is equal to .6 ohm. Perform the following: a) Compute the per-unit equivalent circuit based on the tap setting of the high voltage side with N HV=6000 turns. b) the nominal turns of the high voltage side.(I do not want the PI equivalent circuit).



$V_{HV} = 36.4$

45 MVA

a)

$N_{HV} = 600\ T$

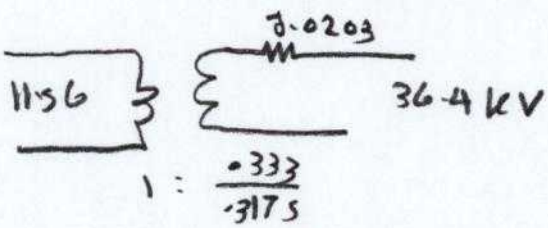
$$a = \frac{2000}{6000} = \frac{1}{3} = 0.333$$

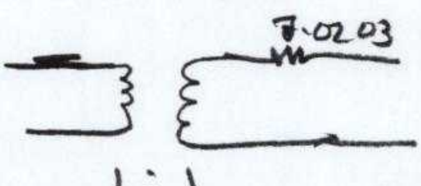
$$b = \frac{11.56}{36.4} = 0.3175$$

$$c = \frac{a}{b} \neq 1$$

$$Z_{bHV} = \frac{V_{bH}^2}{S_b} = \frac{(36.4)^2}{45} = 29.44\ \Omega$$

$$X_{p.u} = \frac{0.6}{29.44} = 0.0203\ \text{p.u}$$





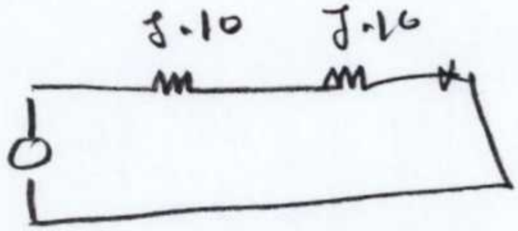
$N_{max} = 6298$

$$a = \frac{2000}{6298} = 0.3175$$

Problem 1. A three phase transformer rated 63 kV (grounded wye) /20 kV(delta) ,100 MVA and 10% short circuit reactance supplied from a grounded power system with short circuit capacity of 1000 MVA. Assume a balanced three phase fault on 20 kV side while the 63 kV side is supplied from the power system at the rated voltage. Compute the short circuit capacity of 20 kV bus.

$$S.C.C_{p.u} = \frac{1000}{100} = 10$$

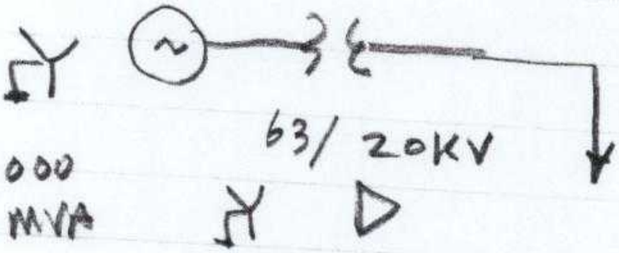
$$X_{th} = \frac{1}{10} = j.10$$



$$S.C.C = \frac{1}{.2} = 5 \text{ p.u}$$

$$S.C.C = 500 \text{ MVA}$$

prob. 1

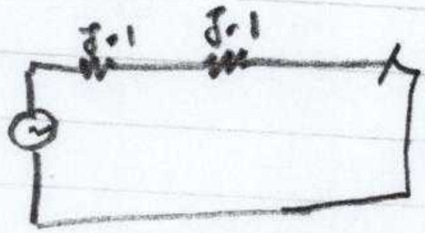


63/ 20KV

1000 MVA

100 MVA

10%



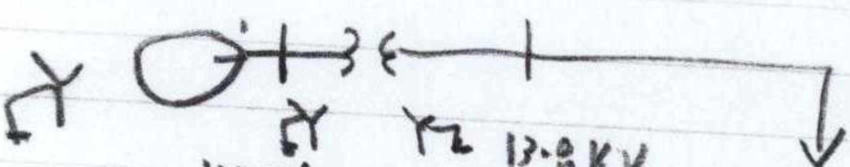
$$S.C.C\ p.u = \frac{1000}{100} = 10$$

$$X_{th} = \frac{1}{10} = .1$$

$$S.C.C_{p.u} = \frac{1}{.2} = \frac{5}{1}\ p.u$$

$$S.C.C = 500\ MVA$$

Prob. 2



1000 MVA

138KV

13.8KV

100 MVA

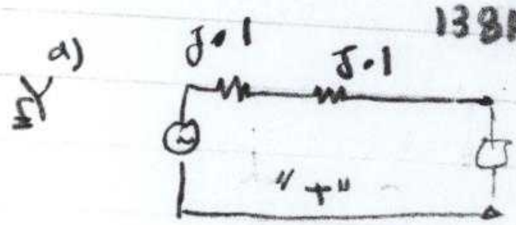
10%

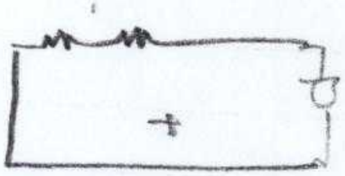
138KV/13.8KV

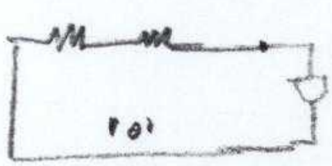
100 MVA $\angle 90$

p.f = 0.8 lagging

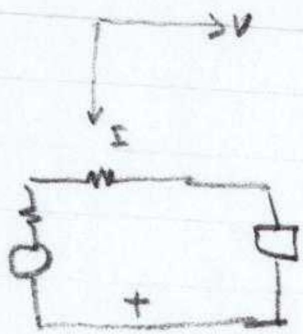
a)

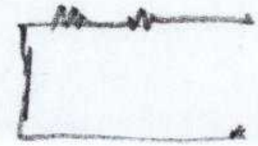




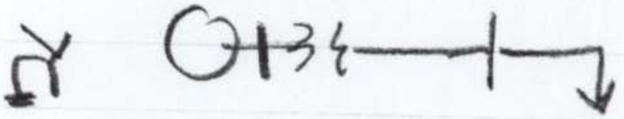


b)





138KV



$S = 100 \angle -90$

Y

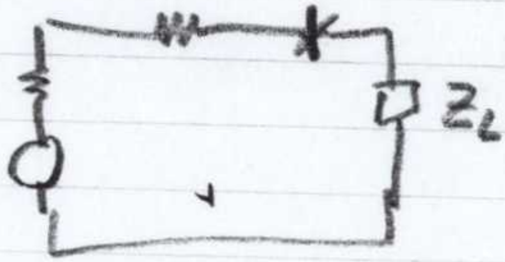
1000 MVA

138/13.8

100 MVA

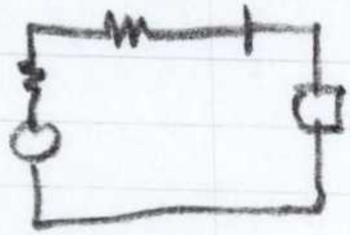
10%

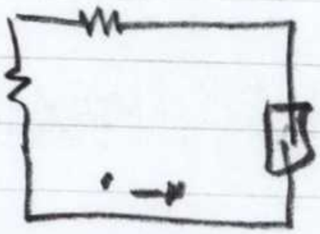
Load

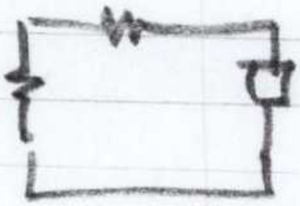


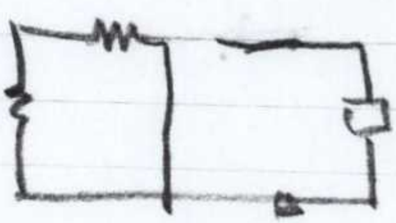
~~Load ground~~

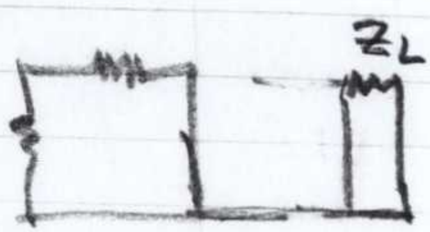
Load Δ











EE740

Name---------------

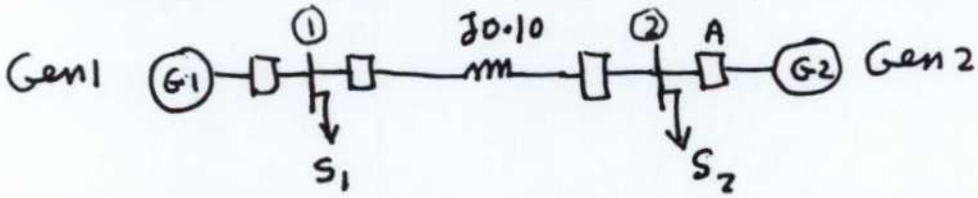
pledge "No aid given,
received, or observed"

Department of Electrical Engineering

The Ohio State University

EE 740 -- Midterm Exam

Problem 1. Consider a power system given below.



The internal impedance of generators is: Zg1 = j 0.10

Zg2 = j 0.20 All values are in p.u.

1.) Compute YBUS model for power flow studies.

2.) Compute ZBUS model for short circuit studies.

Problem 2. For Problem 1,assume the following load and generation schedules:

Loads: S1 = 0.5 + j0.5 p.u., S2 = 0.2 - j0.5 p.u.

Generators: Generator one is the Swing generator and generator 2 scheduled power is P=0.5 p.u.

Use Gauss-Seidel and compute Load Voltage at BUS 2.
Assume V1 = 1.10 p.u. (Give your results for one iteration only.)

Problem 3. For Problem1; assume a three phase fault at BUS 2. Compute the fault current seen by circuit breaker A. Ignore the Loads.

Algorithm for calculations of balanced and unbalanced fault currents.

Step 1: Build the positive sequence $\mathbf{Z}_{bus}$ matrix with reference to ground.

$\mathbf{Z}_{bus(1)}$ 1: positive

Step 2: Build the negative sequence $\mathbf{Z}_{bus}$ matrix. This is normally the same as the positive sequence.

$\mathbf{Z}_{bus(2)}$ 2: negative

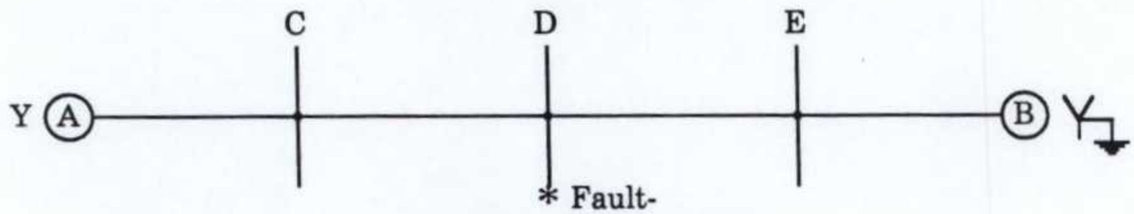
Step 3: Build the corresponding zero sequence $\mathbf{Z}_{bus(0)}$ matrix.

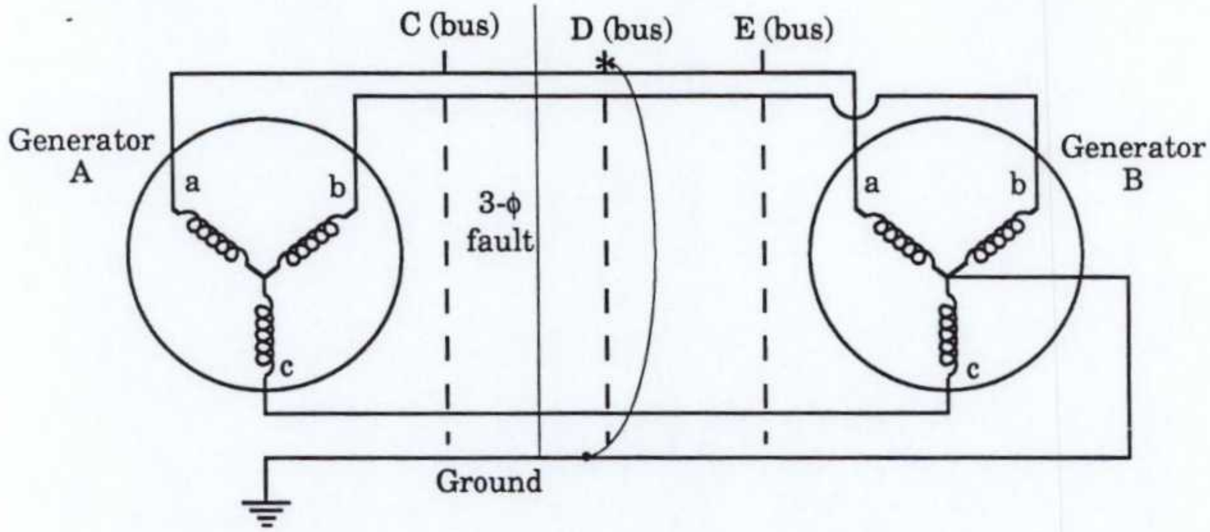
$\mathbf{Z}_{bus(0)}$ 0: zero

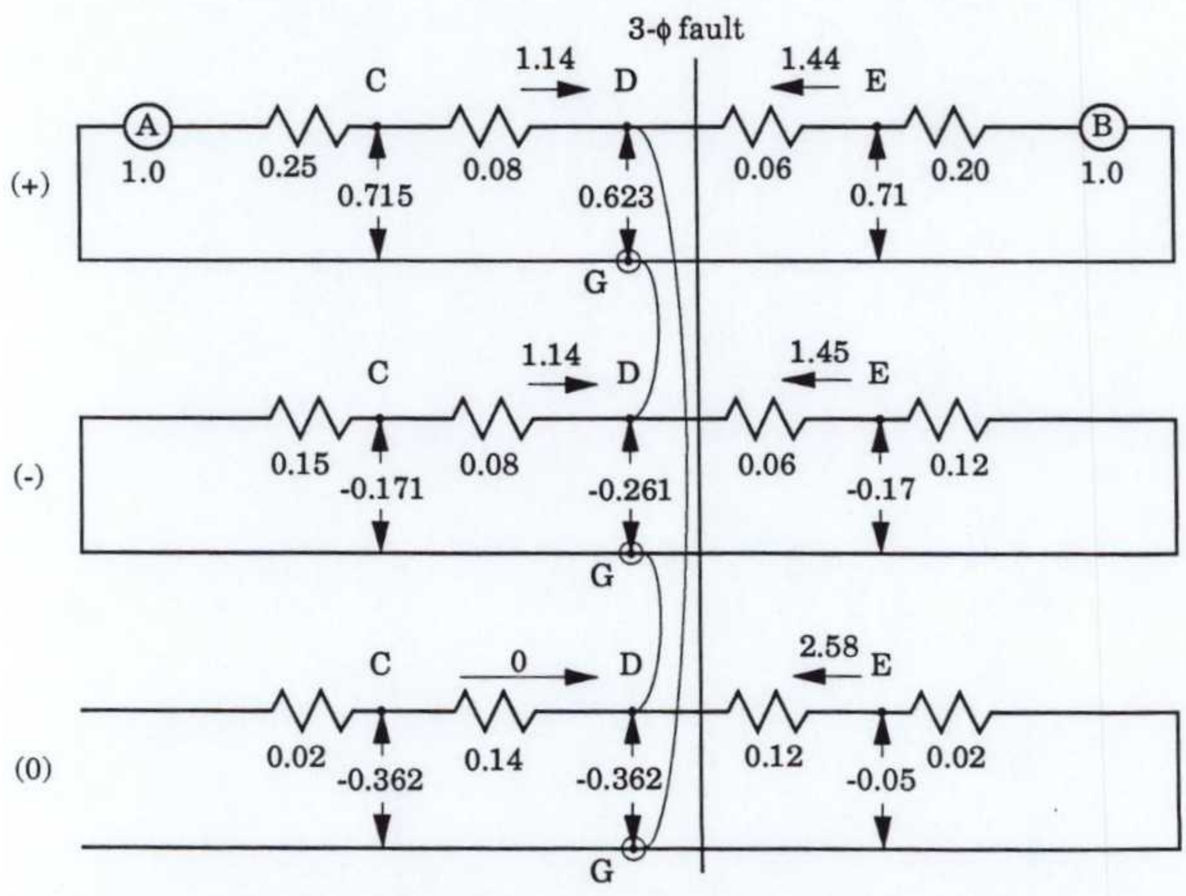
Step 4: For specified fault types, connect the appropriate network sequences and compute the voltage and current flow at the faulted bus.

calculate the fault current based on a given fault type

print the results

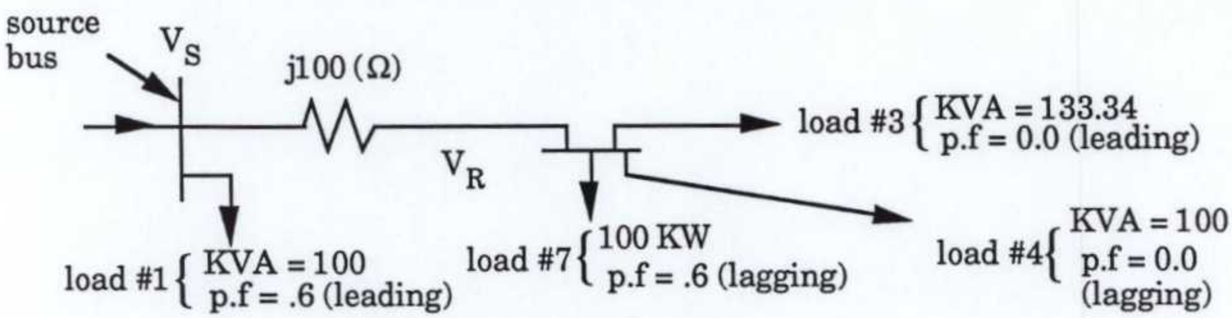

C
D
E
Y A
B
* Fault-
Phase A to ground


C (bus)
D (bus)
E (bus)
Generator A
a
b
c
3-ϕ fault
Generator B
a
b
c
Ground


3-ϕ fault
1.14
1.44
C
D
E
A
B
1.0
0.25
0.715
0.08
0.623
0.06
0.71
0.20
1.0
(+)
G
1.14
1.45
C
D
E
0.15
-0.171
0.08
-0.261
0.06
-0.17
0.12
(-)
G
C
0
D
2.58
E
0.02
-0.362
0.14
-0.362
0.12
-0.05
0.02
(0)
G

QUIZ #1

Problem 1. Consider a 3-ϕ distribution feeder as shown below:



Compute the following:

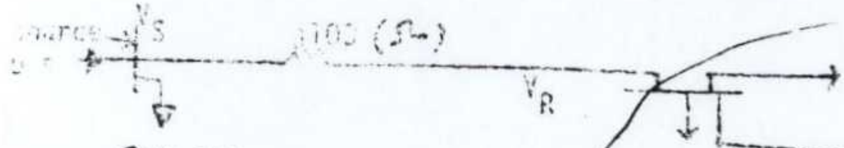
1) The souce voltage V_s, if V_R is to be maintained at 4.4 V (V_R=4.4 kV line value).

2) The source current and power factor at the source.

3) The total complex power supplied by the source

4) How much reactive power should be connected to the source bus for obtaining unity power factor at the source bus?

Problem 1. Consider a 3-φ distribution feeder as shown [redacted]low:



load #3 { KVA = 13.. ; p.f = 0.. }

load #1 { KVA = 100 ; p.f = .6 leading }

$60_{kW} - j\,80$ kvar

load #2 { 100 KW , $S = \frac{100}{.6} = 166.6$ KV [redacted] ; p.f = .6 (lagging) $\theta = 53$ [redacted] ; $Q = 166.67 \sin 53°.1 = 133.3$ [redacted] kvar }

$\bar{S}_3 = 100 + j\,133.34$

[redacted]

Compute the following:

$\hat{S}_R =$ [redacted] kW + j

1) The source voltage V_S, if V_R is to be maintained at [redacted] 4 KV

2) The source current and power factor at the source.

3) The total complex power supplied by the source.

4) How much reactive power should be connected to the so[redacted]rce b obtaining unity power factor at the source bus?

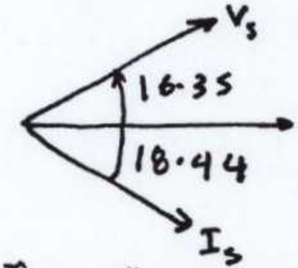
1) $\tilde{V}_{s\phi} = (j100)\,\tilde{I}_{L_R} + 2543\angle 0$

$\bar{S}_R = \sqrt{3}\,\tilde{V}_{L\text{-}L_R}\tilde{I}^*_{L_R}$ $\quad \tilde{I}_{L_R} = \frac{(100+j100)}{\sqrt{3}\; 4.4\angle 0} = 13.14$ [redacted] $j13.1$

$\tilde{V}_{s\phi} = 4.02 \angle 16.35$ KV (L-n) $\quad \hat{V}_{s\,L\text{-}L} = 6$ [redacted] $95\angle 16$

2) $I_s = \tilde{I}_{L_1} + \tilde{I}_{L_R}$ $\quad \tilde{I}_{L_1} = \frac{(\bar{S}_1)^*}{\sqrt{3}\,\tilde{V}^*_{s\,L\text{-}L}} = \frac{(60}{\sqrt{3}}$ [redacted] $\frac{- j80}{6.95\angle}$

$I_s = 16.9 \angle -18.44$ A/φ



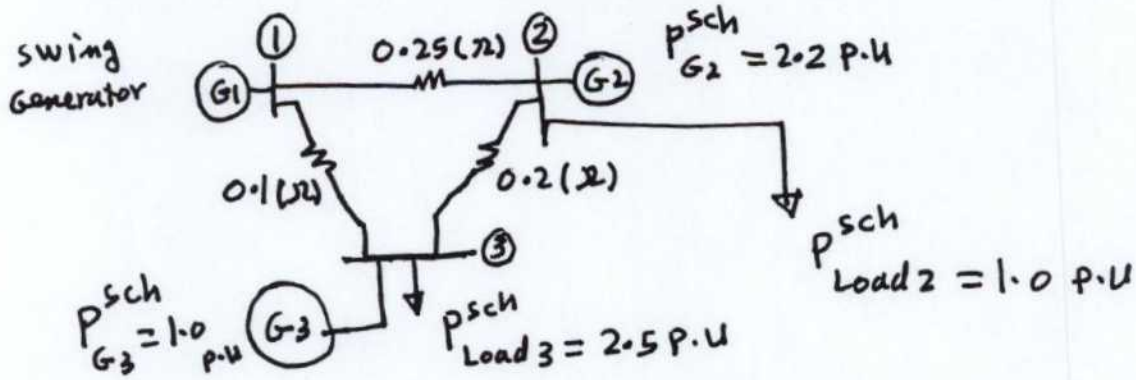
$p.f_s = \cos(16.$ [redacted] $+ 18.$

3) $\bar{S}_s = \sqrt{3}\,\tilde{V}_{s\,L\text{-}L}\,I^*_s = 201.18\angle 34.8$

$= 165.2 + j\,114.82$ (kW) (kvar)

4 $\bar{S}_c = -j\,114.82$ kvar

Problem 4. For the power system given below:



1.) Assume V1 = 1 p.u. Compute V2 and V3 (Use Gauss-Seidel. First iteration only.)

2.) If after ten iterations of Gauss-Seidel V2 = 1.07 p.u. and V3 = 0.91 p.u, Compute:

2.1) Power mismatch at bus1, bus2, and bus3

2.2) Power loss of transmission systems.